APPENDIX 3

System description

CONTENTS

1. SYSTEM OVERVIEW OF LAND-BASED TEST

KT MARINE (Korea Top Marine) has developed the KTM-BWMS (Ballast Water Management System), named MARINOMATE™ BWMS, which is based on electrochemical disinfection and designed to meet the requirements of IMO (International Maritime Organization).

Basic Approval of the MARINOMATE™ BWMS has been submitted to MEPC 63 and the twenty-first meeting of the GESAMP-Ballast Water Working Group (BWWG) reviewed the application for Basic Approval of the MARINOMATE™ BWMS and recommended that Basic Approval of the MARINOMATE™ BWMS be granted.

The land-based test of the MARINOMATE™ BWMS was conducted at a test facility of the Republic of Korea from April to October 2013. The facility, Korea Institute of Ocean Science & Technology (KIOST), is located at Jangmok-myeon, Geoje, Gyeongsangnam-do, Republic of Korea (Figure 1).

Figure 1. Land-based test facility of MARINOMATE™ BWMS

The land-based test facility was established in January 2013 in order to improve an international reliability of the Ballast Water Management System (BWMS) and KIOST is in charge of the maintenance of the facility.

All units of the MARINOMATE™ BWMS are installed in a 20-feet container (the only TRO sensor is installed outside) and the facility of the MARINOMATE™ BWMS has been established in April 2013 after pre-commissioning of the test facility from January until March 2013.

The whole test regarding ballasting and de-ballasting process was conducted by staffs of KIOST according to strict QA/QC and all data during operating was recorded and managed by using log sheets.

MARINOMATE™ BWMS consists of a plankill pipe™ unit, an electrolyzer unit, a neutralization unit and a system control unit and mounted directly in the main ballast line.

During ballasting, inlet water flows through the plankill pipe™ unit by the ballast pump and aquatic organisms are damaged or shocked by physical effects. Damaged aquatic organisms are disinfected passing through the electrolyzer unit which generates Active Substances (AS). In the meantime, the generated AS are automatically monitored by TRO sensor and maximum allowable dosage of the AS concentration is 10 mg/L TRO as Cl_2.

During de-ballasting, a neutralizing agent is injected before discharging the treated water overboard to neutralize the residual chlorine in the ballast tank. Aqueous solution of sodium thiosulfate is used as the neutralizing agent and neutralizing dosages are controlled by PLC and the Maximum Allowable Discharge Concentration (MADC) is kept less than 0.2 mg/L TRO as Cl_2.

The specifications of the land-based test facility and components of MARINOMATE™ BWMS are described in Table 1.

Table 1. Specifications of Land-based test facility and components

No	Item	Q'ty	Unit	Specification	Remarks
1	Ballast pump	1	set	Max. capacity : 500 m^3/hr (1750RPM) Motor : AC 380V/45kw/60Hz Head : 15mH	KIOST
2	De- Ballast pump	1	set	Max. capacity : 250 m^3/hr (1750RPM) Motor : AC 380V/30kw/60Hz Head : 20mH	KIOST
3	Plankill pipe™ unit	1	set	Material : SPP(SCH 40) Connection : 200A flange type Size : 1450 x 319 (L x Ø)	KT Marine
4	Electrolyzer unit	1	set	Material of chamber : SS400, 10T (Epoxy tar coating) Connection : 200A flange type Size : 1483 x 470 x 564 (L x W x H)	KT Marine
5	Neutralization unit	1	set	Material of tank : SUS 316 - Capacity : 60Liter - Size : 480 x 270 x 870 (L x W x H) Neutralizing agent: Sodium thiosulfate - concentration: 25% aqueous solution - Motor : AC 200V/60Hz	KT Marine
6	System control unit	1	set	Material : SS41, 2.3T Size : 900 x 430 x 1600 (L x W x H) Touch screen : 15inch, HMI, PLC	KT Marine
7	Rectifier	1	set	Capacity : 39.6kw (12V, 3300A) Size :1222 x 450 x 1172 (L x W x H) Type : IGBT	KT Marine
8	Test water tank	1	set	Material : SS400 Capacity : 500m^3 Size : Dia11.0m x 5.5mH	KIOST
9	Treated water tank	1	set	Material : SS400 Capacity : 250m^3 Size : Dia7.5m x 6.0mH	KIOST
10	Control water tank	1	set	Material : SS400 Capacity : 250m^3 Size : Dia7.5m x 6.0mH	KIOST
11	Feed tank	1	set	Material : PE Capacity : 5m^3 Size : Dia1.81m x 2.2mH	KIOST
12	Flow meter (Ballasting)	1	set	Model : KTM-800 Size : 300A, flange type Accuracy : ±0.5% Range : 0~1000 m^3/hr	KIOST
13	Flow meter (De-ballasting)	1	set	Model : KTM-800 Size : 200A, flange type Accuracy : ±0.5% Range : 0~500 m^3/hr	KIOST
14	TRO sensor	2	set	Model : CLX-HF Range : 0~10ppm Output : 4-20mA, RS-485 Operation temperature : 5~40℃ Including sampling pump - Pressure boost pump - 1.5L/min	KT Marine

2. OPERATION PROCESS

The operation processes of MARINOMATE™ BWMS are divided into the ballasting process and de-ballasting process. Each process is described below.

The land-based test was performed at a test facility, Korea Institute of Ocean Science & Technology (KIOST), which is located at Jangmok-myeon, Geoje, Gyeongsangnam-do, Republic of Korea. The biological efficacy test, chemical analysis for Disinfection By-Products (DBPs) identification and the aquatic eco-toxicity test were conducted by Korea Marine Equipment Research Institute (KOMERI), Korea Testing & Research Institute (KTR) and Marine Eco-technology Institute (MEI), respectively. All test procedures were supervised by KIOST according to the strict QA/QC.

For a seawater test, natural seawater was taken from south coast near KIOST and natural seawater was mixed with tap water for a brackish water test and a low salinity test(8psu).

When the brackish water and low salinity testing, tap water was filled with the test water tank and then mixed well and aerated using a submerged mixer. After measuring the residual chlorine concentration (0.00 mg/L TRO as Cl_2), the salinity of test water was adjusted by supplying natural seawater.

Before operating, check that the TRO sensor is functioning correctly using ultrapure water and the TRO concentration was 0.00 mg/L TRO as Cl_2 at that time.

2.1 Ballasting Process

For the seawater and brackish water test, a test water tank was filled with natural water taken from south coast near KIOST by a pump and the salinity was measured. Also, the density of aquatic organisms was measured directly on site and injected into a feed tank, and then starch and glucose were added in the test water tank.

After checking the valve line up, the valves involved in the main ballast line were opened. A ballast pump and an electrolyzer unit were turned on at the same time. In the meantime, aquatic organisms in the feed tank are injected into the ballast pipe line by a feed pump. The flow rate of 500 m^3/hr was maintained by a ballast pump and the treated water (250 m^3/hr) and untreated water (250 m^3/hr) were sent to the Treated water tank (T1) and the Control water tank (C1), respectively.

During ballasting process, MARINOMATE™ BWMS was able to generate Active Substances from the electolyzer unit in order to disinfect aquatic organisms. A maximum allowable dosage of TRO (AS) was approximately 10 mg/L TRO as Cl_2. The dosage is sufficient to disinfect the aquatic organisms.

Some electrolyzed water (10 mg/L TRO concentration as Cl_2) after passing through the electolyzer unit is sent to the front of the plankill pipe™ unit and then it is circulated. This circulation process can prevent the formation of biofilms which can attach and grow inside of the plankill pipe™ unit.

For an analysis of gas generated during ballasting process, the gas sampling was carried out at the rear of the electrolyzer unit and the treated water tank (T1). A flow diagram of MARINOMATE™ BWMS ballasting process is described in Figure 2.

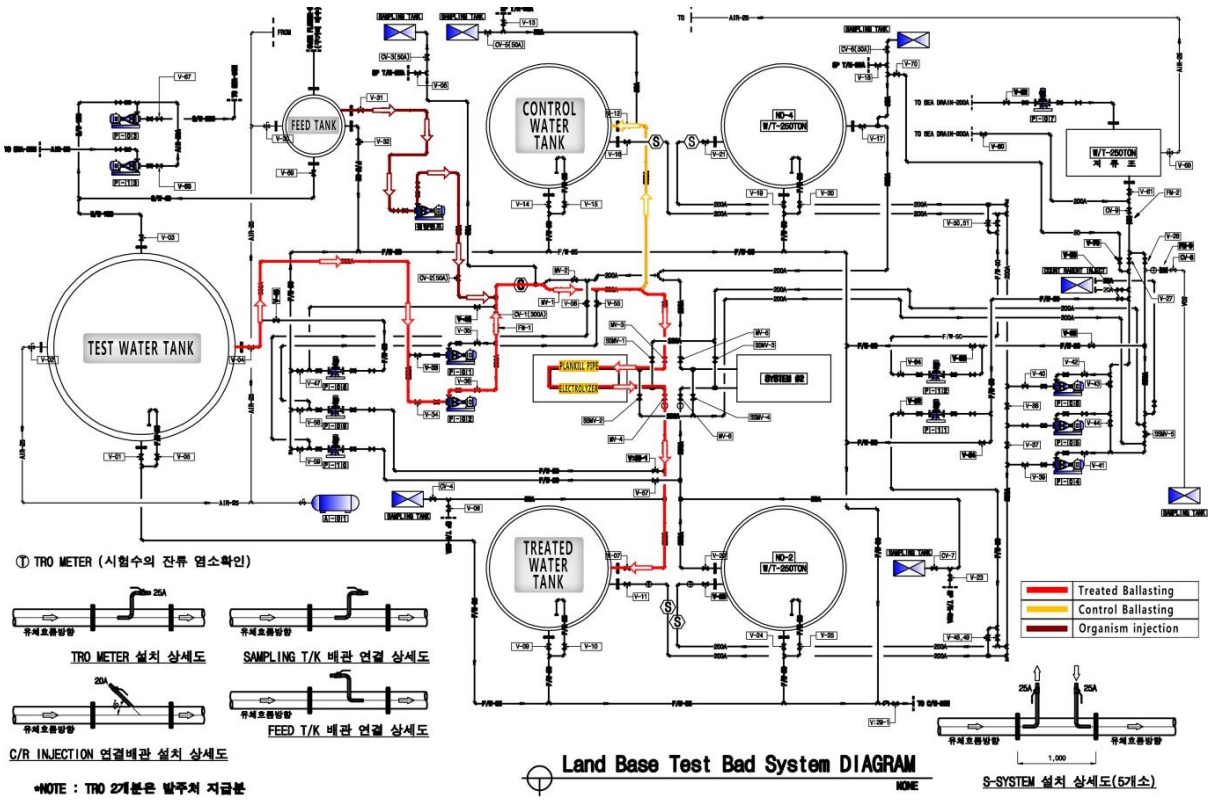


Figure 2. Flow diagram of MARINOMATE™ BWMS ballasting process

2.2 De-ballasting Process

During de-ballasting process, treated water in the Treated water tank (T1) was neutralized passing through a neutralization unit to remove the residual chlorine before discharge. The neutralization process is to minimize harmful effects on marine ecosystems.

As a neutralizing agent, aqueous solution of sodium thiosulfate (concentration: 25%) was used and the dosage was controlled according to the residual TRO concentrations of treated water and discharge flow rates.

Before de-ballasting process, check that the two TRO sensors are functioning correctly using ultrapure water and the TRO concentration was 0.00 mg/L TRO as Cl_2 at that time.

After mixing the Treated water tank (T1), valves of de-ballasting line were checked. Then, the de-ballasting pump was operated.

For de-ballasting process, two TRO sensors are needed to measure the residual TRO

concentration of treated water before and after neutralization. The Maximum Allowable Discharge Concentration (MADC) was maintained less than 0.2mg/L TRO as Cl_2.

Dosages of the neutralizing agent may vary from the residual TRO concentration of Treated water tank (T1) and were injected 190~270 ml/min in the seawater and 20~80 ml/min in the brackish water. The dosage rates were slightly higher than theoretical dosage rates.

A flow diagram of MARINOMATE™ BWMS de-ballasting process is described in Figure 3.

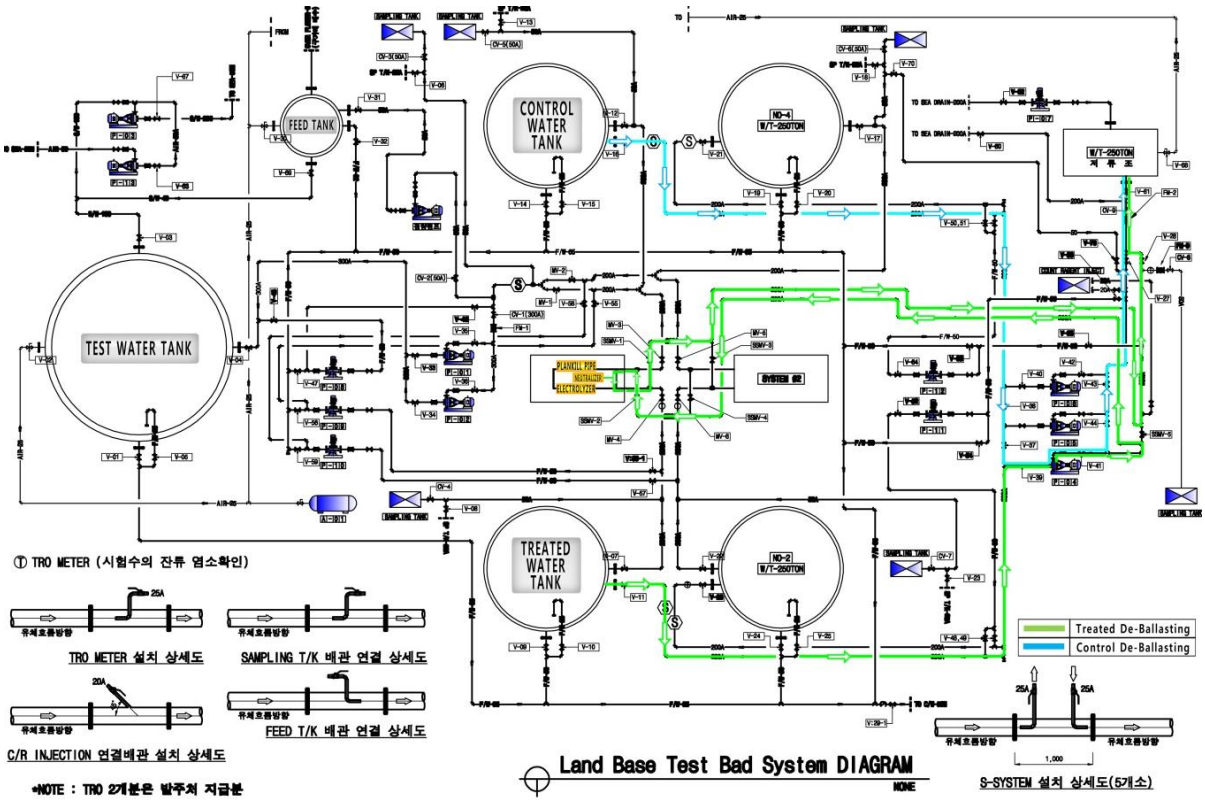


Figure 3. Flow diagram of MARINOMATE™ BWMS de-ballasting process

2.3 Operation Procedure Log-sheet

The land-based test of MARINOMATE™ BWMS for IMO Final Approval was carried out at a test facility, KIOST. All procedure for the test, from start to finish, was conducted by staffs of KIOST under strict QA/QC and the time for each procedure was recorded.

Onsite measurement items are checked by staffs of KIOST and the sampling was sealed and transferred to an analyzing institute with them and also, KIOST staffs conducted QA/QC on on-site until the analysis has been completed.

The log sheets were divided into the ballasting operation and de-ballasting operation and the details of the procedure are described below.

Also, all log sheets on the land-based test of MARINOMATE™ BWMS are described in section 4.

2.3.1 Log sheet of ballasting operation

All log sheets on the land-based test of MARINOMATE™ BWMS are described in section 4.

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test		Mode : Ballasting		Test No. :			
Test water : Sea Water(> 32PSU)				DATE :			
Time	No.	Work	Mode	Value			Remark
	1	Ready to Start	Preparation				
	2	System Check	Preparation	Control Panel / Valves		Rectifier / Electrolyzer	
	3	Test water tank Check	Preparation				
	4	Additives Make-up in Test water tank	Preparation	Starch : Glucose : Silica(TSS) :			Basis : 500㎥
	5	Waiting for Mixing(Test water tank)	Preparation				
	6	Valve Check	Preparation				Treated & Control
	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI		
	8	Organism Injection	Preparation				
	9	TRO Analyzer Check	Preparation				
	10	Valve Line up	Ballasting				Treated & Control
	11	Ready for Electrolyzer	Ballasting	YES		NO	
	12	Valve Open	Ballasting				Treated & Control
	13	Transfer Pump Start	Ballasting				Treated & Control
	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	

Check List for Land-Based Test　　Mode : Ballasting　　Test No. :

Test water : Sea Water(> 32PSU)　　DATE :

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
	19	GAS Sampling of Electrolyzer	Ballasting				
	20	GAS Sampling of Treated Tank	Ballasting				
	21	Electrolysis Unit Shutdown	Ballasting				
	22	Transfer Pump Stop	Ballasting				
	23	Valve Close	Ballasting				Treated & Control
	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

2.3.2 Log sheet of de-ballasting operation

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test			Mode : De-Ballasting	Test No. :		
Test water : Sea Water(> 32PSU)				DATE :		
Time	No.	Work	Mode	Value		Remark
	1	Ready to Start	Preparation			
	2	System Check	Preparation	Control Panel / Valves	Neutralizer	
	3	Treated Water Tank Check	Preparation			
	4	GAS Sampling of Treated Tank	Preparation			
	5	Treated Water Tank Sampling	Preparation			
	6	Mixing of Treated Tank	Preparation			
	7	Prepare of Neutralization reagent	Preparation			
	8	Valve Check	Preparation			Treated & Control
	9	TRO Analyzer Check	Preparation			
	10	Valve Line up	De-Ballasting			Treated & Control
	11	Valve Open	De-Ballasting	Treated	Control	Treated & Control
	12	Transfer Pump Start	De-Ballasting	Treated	Control	Treated & Control
	13	Injection of Neutralization reagent	De-Ballasting			
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	

Check List for Land-Based Test Mode : De-Ballasting Test No. :

Test water : Sea Water(> 32PSU) DATE :

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated	Control	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated	Control	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated	Control	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated	Control	Treated & Control
	19	Valve Close	De-Ballasting	Treated	Control	Treated & Control
	20	Line Drain	De-Ballasting	Treated	Control	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

3. DETAILS OF UNIT

3.1 Plankill Pipe™ Unit

The plankill pipe™ unit is used as a pre-treatment unit, but entirely different form a filter commonly used as the pre-treatment unit. The plankill pipe™ unit works without external power supplies (non-motorized) during the ballasting process.

The plankill pipe™ unit is mounted directly in the main ballast pipe line and a shaft including impellers and baffles is equipped in the pipe. When inlet water passes through the plankill pipe™ unit during ballasting, the shaft is rotated at high speed by inlet flow velocity and turbulence is generated by impellers. Besides, when the impellers rotate, the direction of the inlet water flow is facing towards the wall in the pipe by centrifugal force and secondarily strong turbulence is generated by colliding baffles.

The land-based test was operated at flow rates of 250 m^3/hr (Velocity: 2.2 m/s), the differential pressure (ΔP) of the plankill pipe™ unit was 0.2 kg_f/cm^2 (Inlet pressure: 0.8 kg_f/cm^2, Outlet pressure: 0.6 kg_f/cm^2). The differential pressure of the plankill pipe™ unit has not increased, due to a larger diameter pipe of the part where impellers are located.

Zooplanktons such as *Artemia salina* and *Oithona sp.* are damaged or shocked by physical effect as collision and turbulence, which increase the efficiency of an electrolyzer unit.

The plankill pipe™ unit will be operated by the pressure difference on shipboard. The operation pressure varies depending on the capacity and head of the ballast pump, length and size of installed pipe. The alarm system will activate when 0.5 kg_f/cm^2(pre-setting value) is detected, and if the pressure comes to 0.8 kg_f/cm^2, all systems will be shut down automatically for safety of ships and crews. (Appendix 8. Chapter 9)

Therefore, the crews have to carry out maintenance periodically according to Appendix 8. Chapter 7 in order to not have problems in operating

3.1.1 Efficacy test of the Plankill Pipe™ Unit

The efficacy test of the plankill pipe™ unit was analyzed by Korea Marine Equipment Research Institute (KOMERI). To demonstrate effect of zooplankton by the plankill pipe™ unit, efficacy test has performed 3 times during land-based test. Sample was collected at the front and the rear of the plankill pipe™ unit. Test organism, *Artemia salina;* ≥ 50 μm aquatic organism, was observed for appendage damage and immobilization under microscope. Zooplankton was concentrated by plankton net (diagonal 45 μm mesh size). Sampling volume was 20 L at inlet and outlet sampling port, respectively. Each sample was analyzed in triplicate, and damage rate was calculated as follows;

$$\textbf{Damage rate}\ (\%) = \frac{(\textbf{Inlet individuals} - \textbf{Outlet individuals})}{\textbf{Inlet individuals}} \times \mathbf{100}$$

3.1.2 The results of test

Artemia salina was affected for morphological damage and caused immobilization through the plankill pipe™ unit. Damage rate was 39.4%, 34.5% and 41.4% each cycle.

Test cycle	Inlet (A)	Outlet (B)	Distinction (A)-(B)	Damage rate (%)	Total average
1st test (inds./m3)	21,000	14,000	7,000	33.33	38.01%
	26,000	16,000	10,000	38.46	
	24,000	13,000	11,000	45.83	
2nd test (inds./m3)	84,000	57,000	27,000	32.14	
	81,000	57,000	24,000	29.63	
	87,000	51,000	36,000	41.38	
3rd test (inds./m3)	12,000	7,000	5,000	41.67	
	11,000	8,000	3,000	27.27	
	14,000	6,667	7,333	52.38	

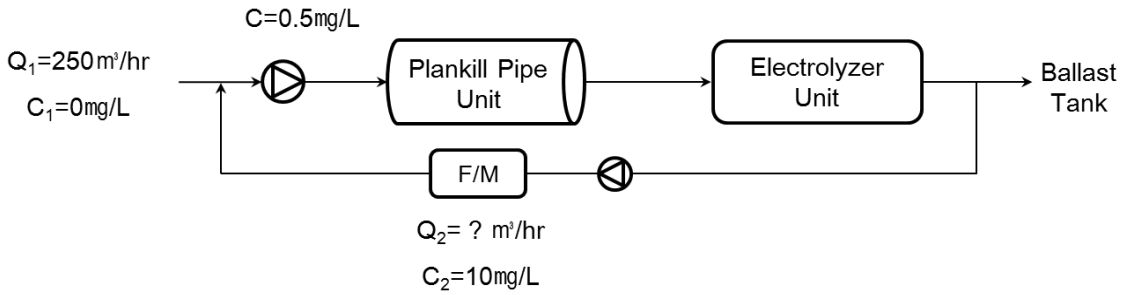
3.1.3 Effect on the circulation system

Basic Approval of the MARINOMATE™ BWMS has been submitted to MEPC 63 and the twenty-first meeting of the GESAMP-Ballast Water Working Group (BWWG) reviewed the application for Basic Approval of the MARINOMATE™ BWMS. In the twenty-first meeting of the GESAMP-BWWG, The group asked how to remove fouling in the plankill pipe™ unit, KT Marine responded that the circulation system will be adapted.

The circulation system serves to send some Active Substances (AS or TRO) generated by electrochemical disinfection of the electrolyzer unit to the front of the plankill pipe™ unit. This system consists of a circulation pump for transferring TRO generated from the electrolyzer unit, a flow meter for measuring flow rates and valves.

During ballasting, the concentration of TRO generated by electrochemical disinfection of the electrolyzer unit is 10 mg/L TRO as Cl_2 and some TRO are sent to the front of the plankill pipe™ unit. Flow rates of the circulation by a circulation pump are calculated by using the equation below and the mixture concentration of TRO at the mixing point (in front of the plankill pipe™ unit) to prevent the formation of biofilms is approximately 0.5 mg/L TRO as Cl_2.

$$Q_m(C) = \frac{Q_1 C_1 + Q_2 C_2}{Q_1 + Q_2}$$



As shown above, when the inlet flow rate is 250 m³/hr and the concentration of the generated TRO is 10 mg/L TRO as Cl_2, to maintain the concentration of 0.5 mg/L TRO as Cl_2 in front of the plankill pipe™ unit, the flow rate of circulation should be kept about 14 m³/hr.

KT Marine was considering on setting the TRO concentration in order to prevent the formation of biofilms. According to *Guidelines for drinking water quality* (2011, 4th edition, WHO), present in most disinfected drinking water at concentration of 0.2~1.0 mg/L chlorine. Consequently, KT Marine decided to keep the residual chlorine concentration of 0.5 mg/L TRO as Cl_2 to prevent securely the formation of biofilms in the ballast pipe line and plankill pipe™ unit.

Therefore, in the land-based test of MARINOMATE™ BWMS for IMO Final Approval, the circulation flow rate of the circulation system was kept 14 m³/hr to generate the TRO concentration of 0.5 mg/L TRO as Cl_2 at the mixing point (in front of the plankill pipe™ unit).

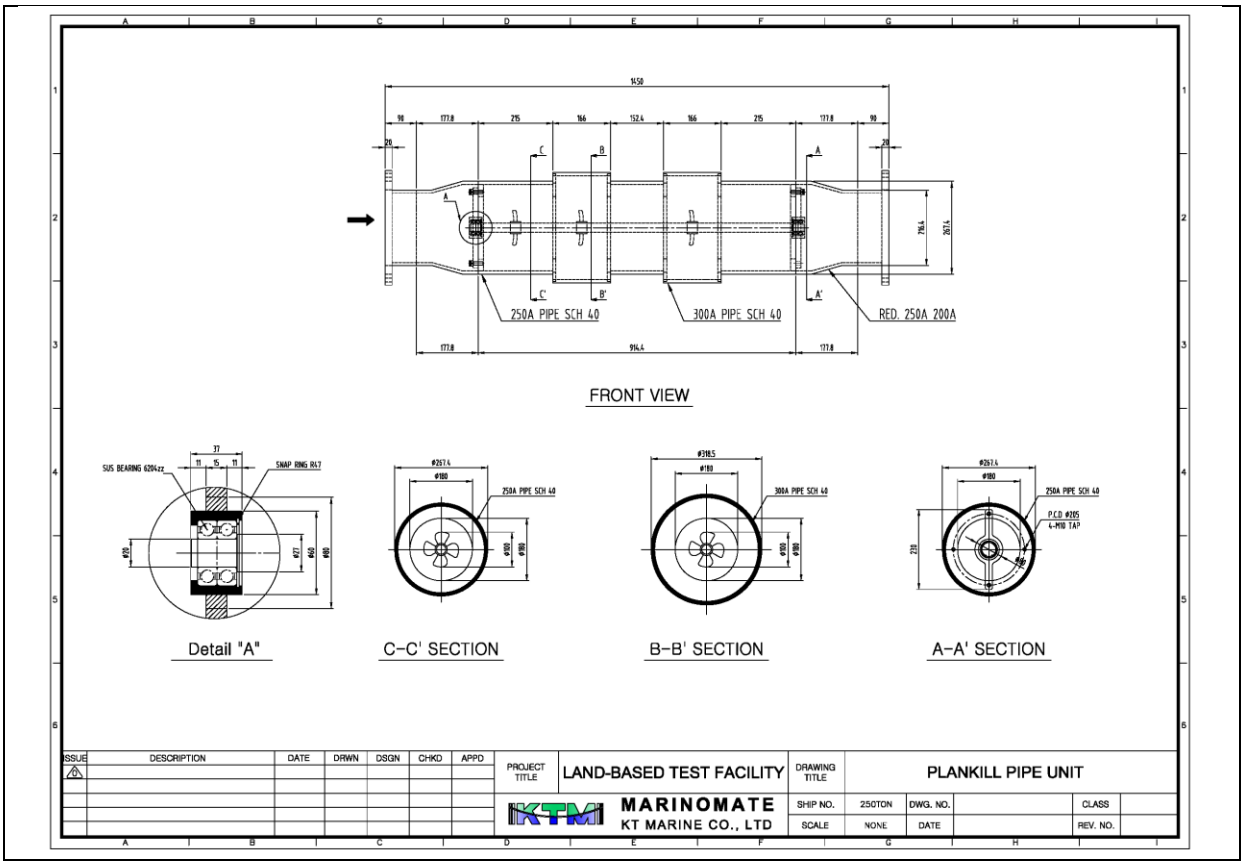
The circulated flow rate (14 m³/hr) and TRO (0.5 mg/L) will not accumulate in the electrolyzer unit because power supply of the rectifier is automatically controlled to keep the maximum allowable dosage (10 mg/L TRO as Cl_2) of rear of the electrolyzer unit.

Also, when some Active Substances generated by an electrolyzer unit are sent to the front of the plankill pipe™ unit, the effects on Disinfection By-Products (DBPs) generated by using the electrolyzer unit again were evaluated and analyzed by Korea Testing & Research Institute (KTR). The chemical analysis test was conducted to confirm changes in concentration of by-products between circulation condition and non-circulation condition in the facility of the MARINOMATE™ BWMS for the land-based test. In the circulation condition, the circulation flow rate was kept 28 m³/hr to generate the TRO concentration of 1.0 mg/L TRO as Cl_2 at the mixing point (in front of the plankill pipe™ unit) in order to verify performance in a worse condition.

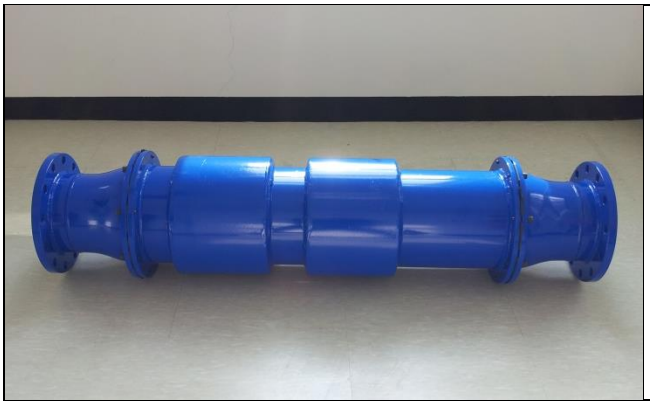
As shown in the table below (the details of analysis are described in Appendix 5), the result of the chemical analysis indicates that concentration of by-products generated between in the circulation condition and non-circulation condition have not changed dramatically. Also, the land-based test was carried out at lower circulation flow rate and concentration than the worse condition mentioned above, such as circulation flow rate of 14 m³/hr and the TRO concentration of 0.5 mg/L TRO as Cl_2, respectively. Therefore, changes in by-products are expected to be less.

Substances	Non-circulation condition (Before plankill pipe™ unit)	Circulation condition (After plankill pipe™ unit)
	D0 concentration (μg/L)(2013. 04. 04)	
Bromate	175	151
Trichloromethane	N.D.	N.D.
1,2-Dichloroethane	N.D.	N.D.
1,2-Dichloropropane	N.D.	N.D.
Dichlorobromomethane	N.D.	N.D.
Dibromochloromethane	N.D.	0.81
Tribromomethane	117	101
1,2,3-Trichloropropane	N.D.	N.D.
Monochloroacetonitrile	N.D.	N.D.
Monobromoacetonitrile	0.20	0.20
Tribromoacetonitrile	N.D.	N.D.
Dichloroacetonitrile	N.D.	N.D.
Bromochloroacetonitrile	0.10	0.11
Dibromoacetonitrile	8.49	9.38
Tribromoacetonitrile	1.04	1.17
Bromodichloroacetonitrile	N.D.	N.D.
Dibromochloroacetonitrile	N.D.	N.D.
Chloral hydrate	N.D.	N.D.
Chloropicrin	0.02	0.02
Monochloroacetic acid	N.D.	N.D.
Monobromoacetic acid	2.22	2.11
Dichloroacetic acid	N.D.	N.D.
Dalapon	N.D.	N.D.
Trichloroacetic acid	3.64	3.52
Bromochloroacetic acid	4.88	4.58
Dibromoacetic acid	1.82	1.92
Bromodichloroacetic acid	42.5	41.4
Chlorodibromoacetic acid	4.95	4.88
Tribromoacetic acid	26.8	27.3

3.1.4 Drawing



3.1.5 Specification



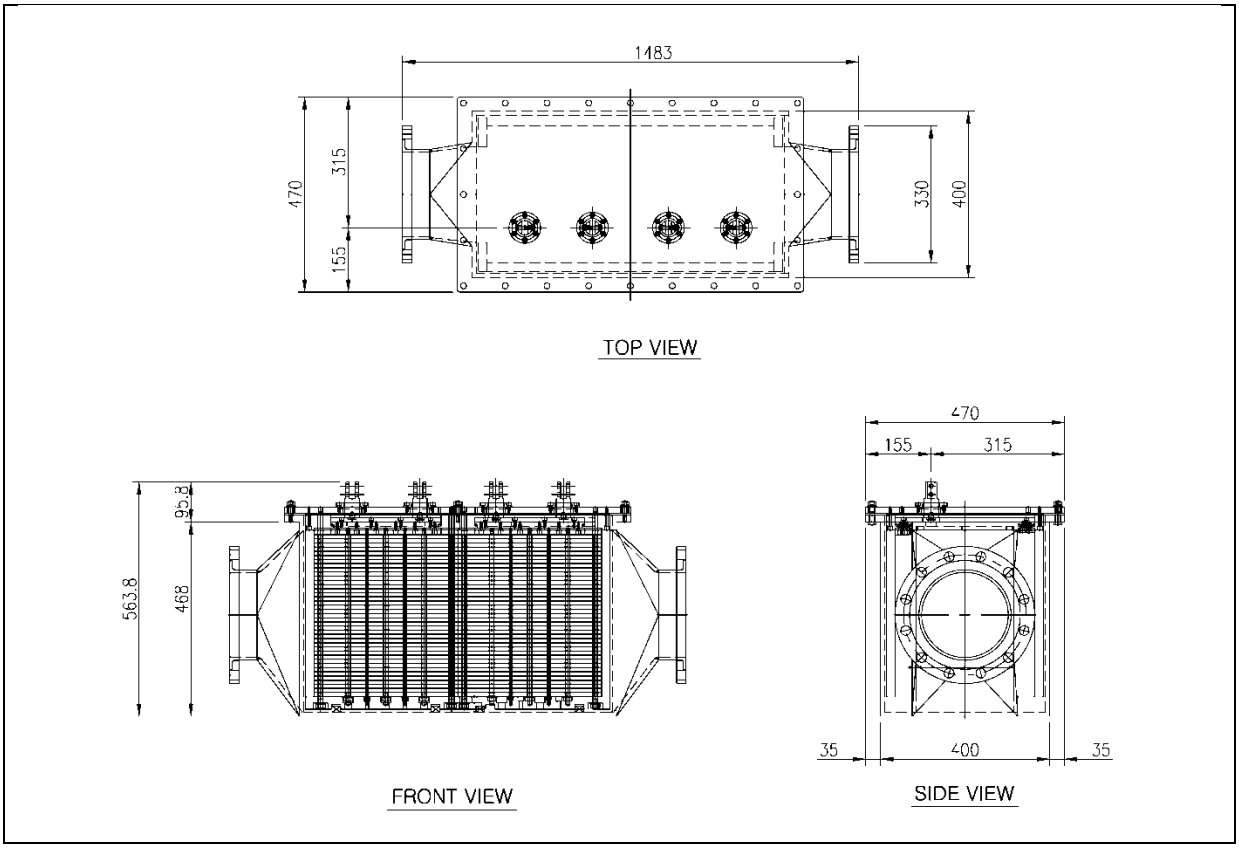
- Material :SPP (SCH40)
- Connection : Flange type
- Pipe Diameter : 200A (8 inch)
- Size : 1450 x 319 (L x Ø)
- Composition : Shaft, Impellers, Baffles
- Differential Pressure (ΔP) :
  Approximately 0.2 kg_f/cm^2 (at 250 m^3/hr)

3.2 Electrolyzer Unit/ Gas Ventilation System

An electolyzer unit of MARINOMATE™ BWMS is installed directly in the main ballast line. During the electrolysis process, Active Substances (AS) are generated and these AS are effective in disinfecting aquatic organisms in the ballast water. In addition, the residual AS in the treated water can inhibit re-growth of organisms in the ballast tank.

For electrochemical disinfection, power is supplied to the electrolyzer unit by using a rectifier. During ballasting process, the treated water passed through the electrolyzer unit is measured by the TRO sensor and can be monitored by a system control unit. Also, the system control unit, which is based on Programmable Logic Control (PLC) and Human Machine Interface (HMI), has a feed-back system for adjusting power supply automatically according to the TRO concentration.

3.2.1 Drawing of Electrolyzer Unit



3.2.2 Specifications of Electrolyzer Unit

- Material of chamber : SS41
  (Internal : Epoxy tar coating)
- Connection : 200A Flange type
- Flange : JIS 10K
- Size : 1483 x 470 x 564 (L x W x H)
- Material of electrode : Titanium
- Material of side support : PP
- Busbar : Brass 6t, 10t
- Gasket(packing) : Rubber 2.4t

During electrochemical disinfection of an electrolyzer unit, hydrogen gas (H_2) as a by-product is produced at the cathode. Hydrogen gas is nontoxic, non-taste and colorless, but high explosive at a very wide range of concentrations between 4% and 75% by volume. Therefore, hydrogen gas should be properly vented to the outside whenever it is generated.

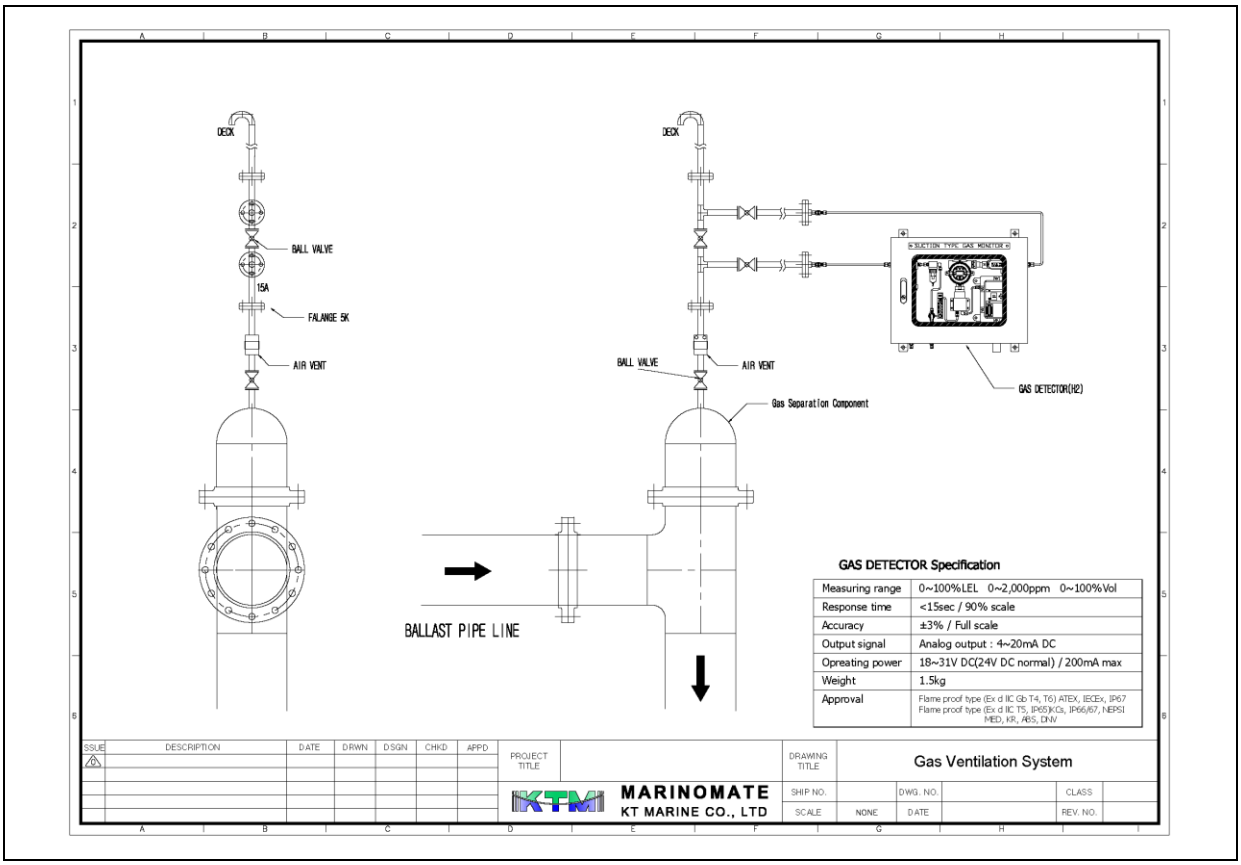
In the land-based test, a gas separation component was installed for measuring the amount of hydrogen gas collection and after checking the amount of gas collection, gas sampling was carried out. But for shipboard test, the gas ventilation system of the MARINOMATE™ BWMS includes a gas separation component, an air vent system for separating gas from water and a gas detector system for measuring the concentration of separated hydrogen gas.

The treated water flows vertically along the pipeline and then, it needs to move below to the ballast tank. In the meantime, the hydrogen gas moves with some of the treated water to empty spaces of the gas separation component because the specific gravity of hydrogen gas is lower than that of water. An air vent system which is located on top of the gas separation component will separate hydrogen gas from water and vent hydrogen gas only. The vented hydrogen gas moves the gas detector along the pipeline. In order to perform this function, the air vent system should be installed vertically. The gas detector is an auto sampling type which includes a diaphragm pump so that the concentration of hydrogen gas can be automatically measured and vented overboard. The gas detector is linked to a system control unit and an alarm system of the system control unit is activated when 1% of hydrogen gas concentration is detected and if the hydrogen gas concentration is over 2%, all systems are shut down automatically and immediately for safety of ships and crews.

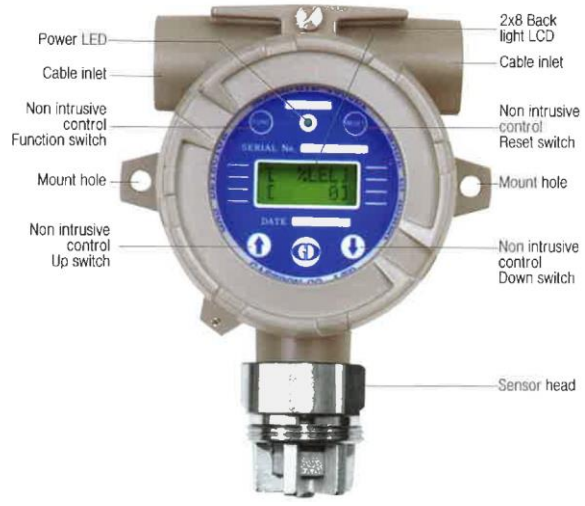
Also, apart from the gas ventilation system including a gas detector, the hydrogen gas detector will be added supplementally in a pump room or engine room where the MARINOMATE™ BWMS will be installed. If the connections of the electrolyzer unit to the pipe, gas separation component to air vent and hydrogen gas detector to flexible hose are successfully installed, hydrogen gas outflow will not occur. But a dangerous situation can occur if it is not properly installed.

Therefore, the hydrogen gas detector installed additionally will detect and activate the alarm system and if necessary all system will be shut down.

3.2.3 Drawing of Gas Ventilation System



3.2.4 Specifications of Gas Detector



- Measuring type: Auto sampling type
- Measuring range: 0 ~ 100% LEL
- Accuracy: ± 3 %
- Display: LED display
- Output signal: 4 ~ 20 mA DC
- Operating temperature: -40ºc ~ 80ºc
- Operating humidity: 5 ~ 99 % RH
- Operating power:
  normal 24V DC / 200 mA
- Weight: 1.5 kg
- Dimensions:
  650 x 500 x 200 mm (L x W x D)
  / outside cover
  136 x 166 x 110 mm (L x W x H)
  / only detector

3.3 Rectifier

A rectifier of MARINOMATE™ BWMS will be made by custom-order which ranges from 0 to 12 V of voltages and from 0 to 3300 A of currents.

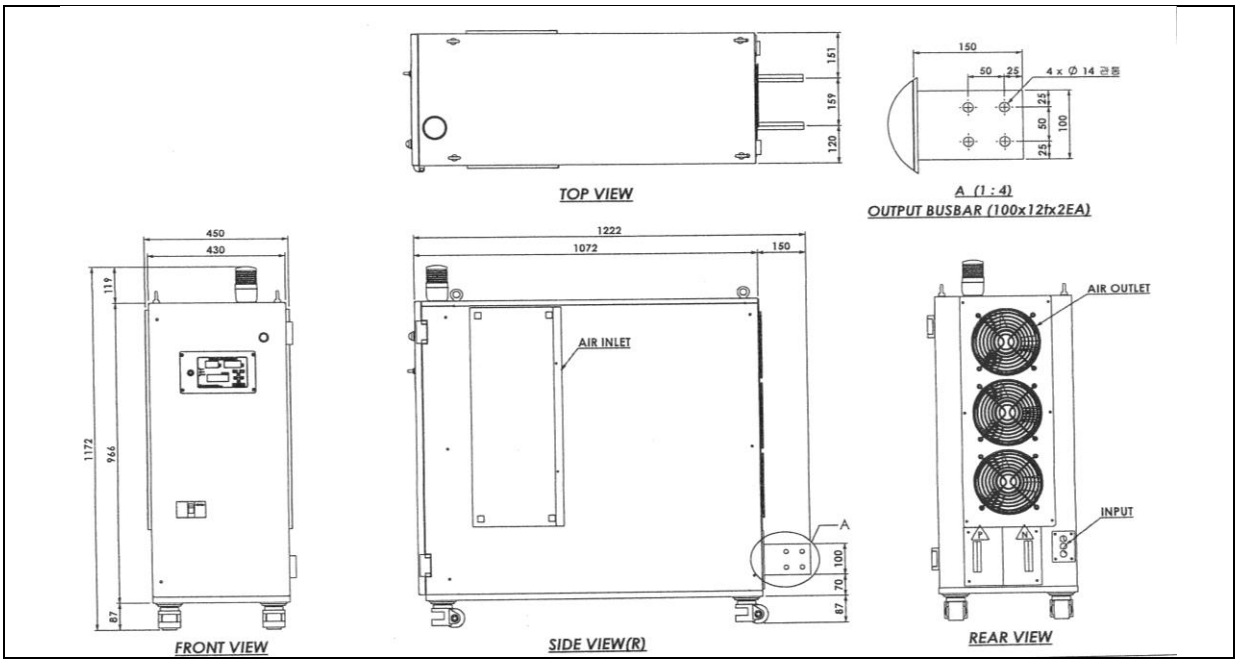
A rectifier is an electrical device that converts from alternating current (AC) to direct current (DC) and provides the power and designed to adjust concentrations of TRO generated by electrochemical disinfection during ballasting.

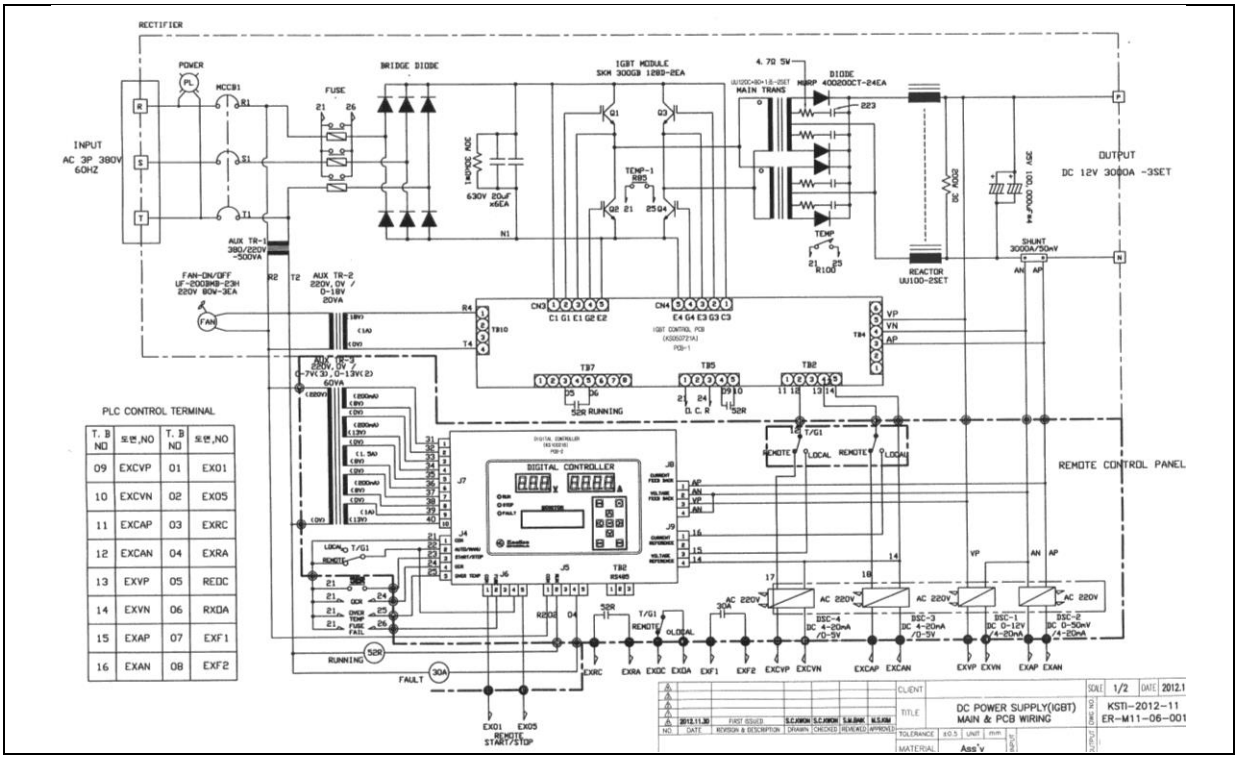
The changes in voltage and current of the rectifier supplying to the electrolyzer unit are adjusted automatically by PLC of the system control unit. This feed-back control is operated according to the TRO concentration generated by the electrolyzer unit.

The rectifier of MARINOMATE™ BWMS is a variable type and operated by a constant current control system.

During ballasting process, the power supply consumption of brackish water tests was increased more by approximately 13% than the power supply consumption of seawater tests.

3.3.1 Drawing





T. B NO	모번,NO	T. B NO	모번,NO
09	EXCVP	01	EX01
10	EXCVN	02	EX05
11	EXCAP	03	EXRC
12	EXCAN	04	EXRA
13	EXVP	05	REDC
14	EXVN	06	RXDA
15	EXAP	07	EXF1
16	EXAN	08	EXF2

3.3.2 Specifications

- Rectifier type: IGBT type
- Size: 1222 x 450 x 1172 mm (L x W x H)
- Capacity: DC 12V, 3300A (39.6Kw)
- Input: AC 3P 380V, 60Hz
- Power factor/ efficiency : 98 % / 98 %
- Voltage and current stability : V ±1 % / A ± 1%
- Current sensing method : shunt 50 mV
- Other:
  - Remote controller
  - IGBT control
  - Alarm light

3.4 TRO sensor

During ballasting process of seawater or brackish water, Active Substances (AS) are generated by electrochemical disinfection of the electrolyzer unit.

The Active Substances (AS) are used for disinfecting aquatic organisms in the seawater or brackish water and shall be maintained proper concentration to disinfect aquatic organisms by using the on-line TRO sensors.

The TRO sensor of MARINOMATE™ BWMS has been designed to meet the design criteria specified by *Standard Methods of the Examination of Water and Wastewater (21th Edition) Method 4500-Cl G. DPD Colorimetric Method.* This TRO sensor uses a 515 nm LED as the measurement light source.

For ballasting process, a TRO sensor is installed at the rear of the electrolyzer unit. For de-ballasting process, two TRO sensors are needed to measure residual TRO concentration of treated water before and after neutralization.

Before the ballasting and de-ballasting process, the TRO concentration was measured using ultrapure water to see if the TRO sensor is functioning correctly and the concentration level of the TRO sensor was 0.00 mg/L TRO as Cl_2 at that time.

TRO sensors can be added depending on the location and configuration of pipelines.

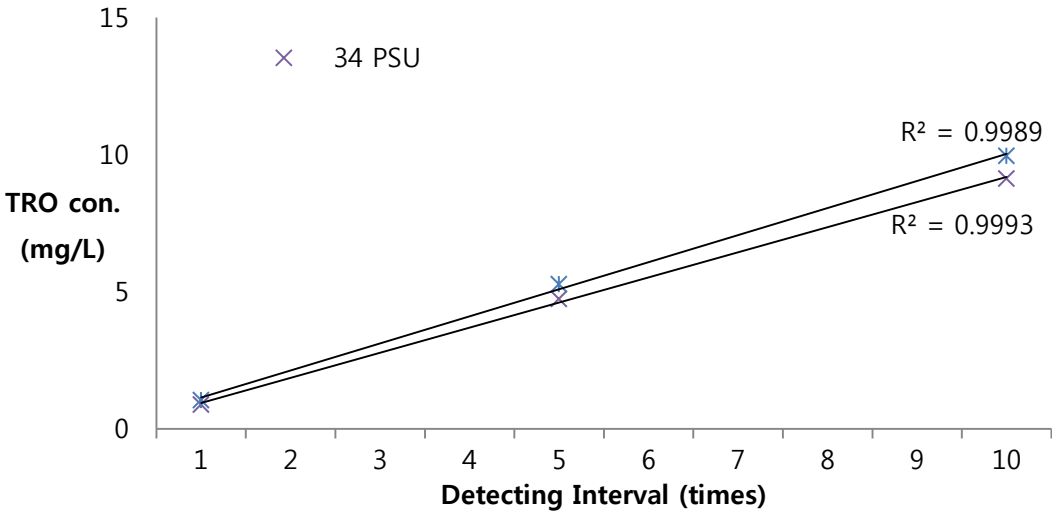
3.4.1 Specifications

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>After electrolyzer unit</td><td>After neutralization unit</td></tr>
<tr><td colspan="2">▪ Measurement range : 0 ~ 10.00 mg/L
▪ Resolution : 0.01 mg/L
▪ Cycle time : 110 seconds to 10 minutes
(use 120 seconds)
▪ Display : Multi-line Liquid Crystal Backlit Display
▪ Analog output : 4 ~ 20 mA , 600 Ω
▪ Water pressure : 0.34 ~ 10.3 bar
▪ Flow rate to waste : 200 ~ 400 mL/min
▪ Operating temperature : 5 ~ 40 ℃
▪ Power supply : 100 ~ 240V AC, 47 ~ 63 Hz
▪ Enclosure rating : IP66 / NEMA 4X</td></tr>
</table>

3.4.2 Calibration of TRO sensor

34 psu	TRO	D.I. Water	TRO
1 mg/L	0.85	1 mg/L	1.07
	0.85		1.07
	0.90		1.06
	0.91		1.06
	0.89		1.05
	0.88		1.04
	0.86		1.03
	0.87		
	0.87		
Average	**0.88**	**Average**	**1.05**
5 mg/L	4.64	5 mg/L	5.28
	4.65		5.30
	4.81		5.29
	4.75		5.26
	4.78		5.31
	4.76		5.28
	4.80		5.22
	4.76		5.28
	4.75		5.25
Average	**4.74**	**Average**	**5.27**
10 mg/L	9.06	10 mg/L	9.87
	9.17		9.90
	9.46		9.94
	9.06		10.11
	9.30		9.91
	8.52		10.03
	9.18		
	9.26		
Average	**9.13**	**Average**	**9.96**

<Calibration graph>



3.5 Neutralization Unit

During de-ballasting process, the neutralization unit of MARINOMATE™ BWMS serves to reduce residual chlorine of the treated water in the ballast tank before discharging overboard in order to neutralize similar to the concentration of natural seawater.

Two TRO sensors are used for measuring residual TRO concentration before and after neutralization during de-ballasting. One TRO sensor (TRO #1) is used for measuring residual TRO concentration before neutralization. The other TRO sensor (TRO #2) after neutralization is used for monitoring that residual TRO has been properly neutralized.

As a neutralizing agent, aqueous solution of sodium thiosulfate (concentration: 25%) is injected and the dosing rate is adjusted by de-ballasting flow rates and residual TRO concentration in the ballast tank. In addition, the residual TRO concentrations after neutralization (TRO #2) are controlled by using PLC and HMI of the system control unit.

The neutralizing agent is directly injected into the de-ballast pipe line by a dosing pump. As a result, the Maximum Allowable Discharge Concentration (MADC) of TRO in the discharge water is kept less than 0.2 mg/L TRO as Cl_2.

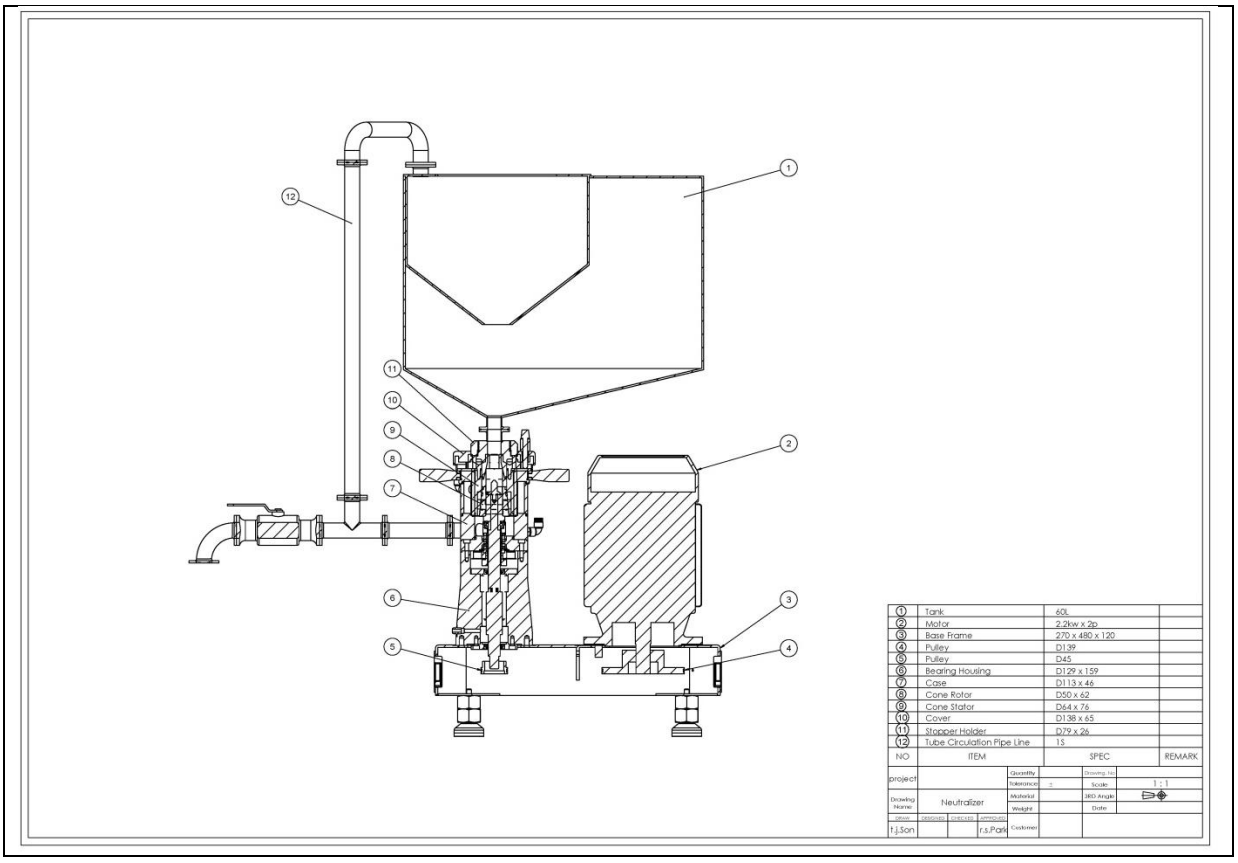
Sodium thiosulfate pellets are easily soluble in water but need more time to make high concentration of them. With that, aqueous solution of sodium thiosulfate has been used.

Aqueous solution of sodium thiosulfate is no any risk to the safety of ships during storage and handling processes. But when refilling the neutralizing tank with a neutralizing agent and connecting/ disconnecting before and after loading, ship's crew deals with the neutralizing agent. Before handling the neutralizing agent, the crews should wear Personnel Protective Equipment (PPE) including protective eyewear, rubber gloves, rubber shoes and hard hats.

If eye contact occurs while handling, flush the eyes with plenty of water for at least 15 minutes. When in contact with skin, it is also need to be flushed with plenty of water for at least 15 minutes.

The details of loading, storage of the neutralizing agent and Personnel Protective Equipment (PPE) are described in Appendix 8 "Operation manual" section 5.2.3.

3.5.1 Drawing



3.5.2 Specifications

- Tank capacity : 60 liter
- Size : 480 x 270 x 870 (L x W x H)
- Neutralizing agent :
  aqueous solution of sodium thiosulfate (25%)
- Tank material : SUS 316
- Motor : 2.2Kw x 2P, 60Hz,
  Max. 8400 rpm
- Max. flow rate : 3000 ml/min

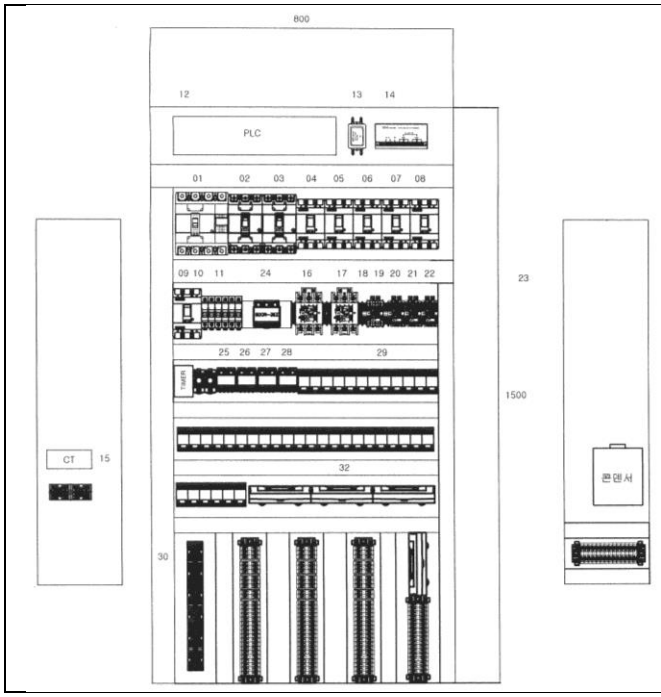
3.6 System Control Unit

The system control unit automatically monitors and controls the status of the MARINOMATE™ BWMS during ballasting and de-ballasting process. This unit is linked to a flow meter, a conductivity meter, TRO sensors and various pumps, so the values obtained from them can be recorded and saved. Also, the system control unit is designed to choose the auto mode or the manual mode.

During ballasting and de-ballasting process, an operator can operate the unit according to the operation logic (see the Appendix 8 “Operation manual”) of Programmable Logic Controller (PLC) of the system control unit and manipulate system via the touch screen of Human Machine Interface (HMI)

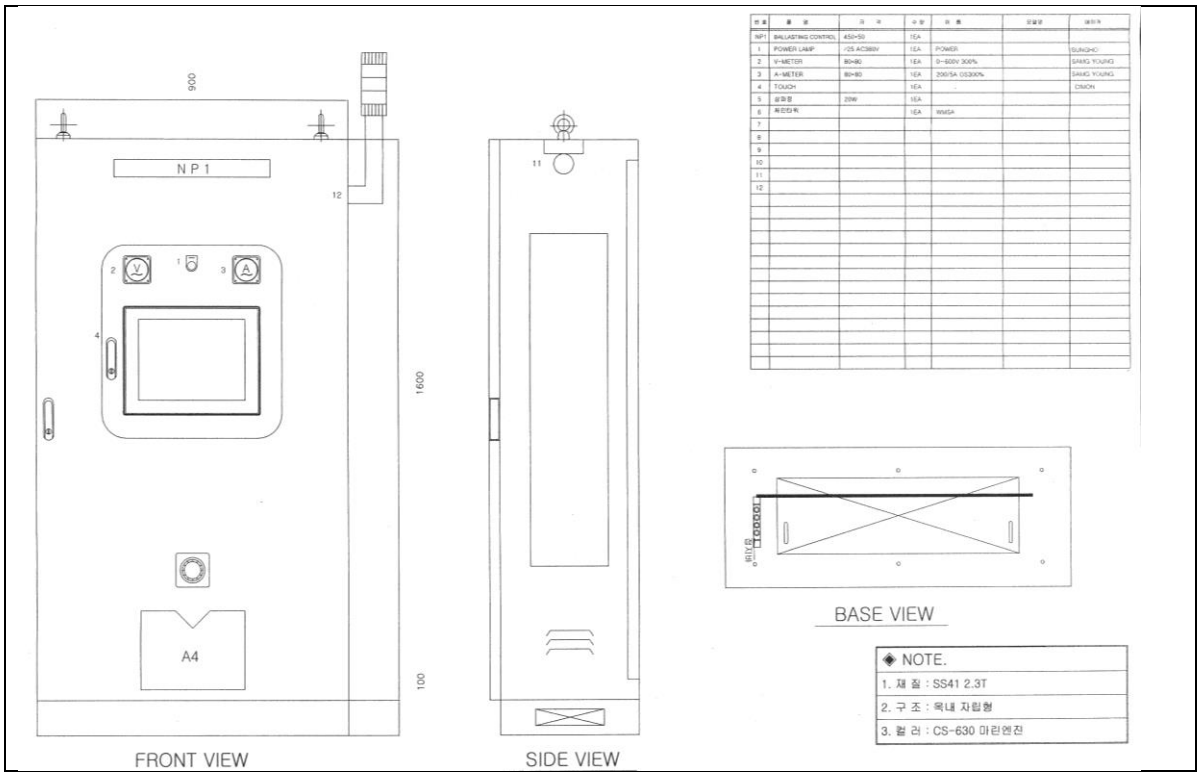
Alarm systems are activated when problems or malfunctions are caused during operation, so the operator can easily recognize. Furthermore, in the event of an emergency, the system of MARINOMATE™ BWMS will automatically shut down.

3.6.1 Drawing



LIST OF INNER PART

번호	DESCRIPTION	SPECIFICATION	Q'ty	REMARK
1	MCCB	ABS 204AF/200AT	1 EA	LSIS
2	MCCB	ABS 103F/100AT	1 EA	LSIS
3	MCCB	ABS 103AF/100AT	1 EA	LSIS
4	MCCB	ABS 53AF/50AT	1 EA	LSIS
5	MCCB	ABS 33AF/30AT	1 EA	LSIS
6	MCCB	ABS 33AF/20AT	1 EA	LSIS
7	MCCB	ABS 33AF/20AT	1 EA	LSIS
8	MCCB	ABS 33AF/20AT	1 EA	LSIS
9	MCCB	ABS 33AF/10AT	1 EA	LSIS
10	BKM 01	2P-10A	1 EA	LSIS
11	BKM 02 ~ 03	2P-5A	2 EA	LSIS
12	PLC	XGT	1 EA	LSIS
13	N.F	SN-E10H	1 EA	화인선트로
14	P.S	VSF150-24	1 EA	화인선트로
15	CT	200/5A	1 EA	삼영
16	MC 01	GMC - 65	1 EA	LSIS
17	MCY	GMC - 65	1 EA	LSIS
18	MCD	GMC - 50	1 EA	LSIS
19	MC 02	GMC -22	1 EA	LSIS
20	MC 03	GMC -12	1 EA	LSIS
21	MC 04	GMC -12	1 EA	LSIS
22	MC 05	GMC -09	2 EA	상호
23	FUSE 01 ~ 02	2A	2 EA	상호
24	EOCR01	EOCRSS	1 EA	삼화
25	EOCR02	EOCRSS 30	1 EA	삼화
26	EOCR03	EOCRSS 30	1 EA	삼화
27	EOCR04	EOCRSS 30	1 EA	삼화
28	EOCR05	EOCRSS 05	1 EA	삼화
29	RELAY	SHR-MY4SN	50 EA	상호
30	T/B	TERMINAL BLOCK	1 LOT	상호
31	TR	380/220V 10KVA	1 EA	상호
32	PLC T/B		4 EA	LSIS
33	콘덴서	380/200uF	1 EA	상호
34	TIMER	Y-△ TIMER	1 EA	상호
35				
36				



3.6.2 Specifications

- Material : SS41
- Thickness : 2.3T
- Touch Screen : 15 Inch, 220V 60Hz IP65
- OS Support : Windows XP/ CE
- Main Source : 380 V, 3ø
- Size : 900 x 430 x 1600 (L x W x H)
- Operating Mode : Auto/ Manual
- PLC : AC 220V (Base: 12 slot)
  - Digital module of Input / Output : DC 240V, 4mA, 32 points)
  - Analog module of Input / Output : current input (DC 4 ~ 20 mA)
  - CPU module : RS-232C, 9 pin, AC 220V, 16Ksteps, 1536 points, 84 ns/step
  - Ethernet : 10/100 Base-TX , Modbus TCP support, 410 mA
  - Operation temperature : 0 ~ 55℃
  - Operation humidity : 5 ~ 95% RH
- Others :
  - MCCB, EOCR, RElay, Condenser, Converter

4. OPERATION PROCEDURE LOG SHEET OF LAND-BASED TEST

4.1 Operation procedure log sheet

4.1.1 Sea water

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test | Mode : Ballasting | Test No. : Seawater-1

Test water : Sea Water(> 32PSU) | DATE : 2023. 5. 30

Time	No.	Work	Mode	Value				Remark
09:30	1	Ready to Start	Preparation					
09:35	2	System Check	Preparation	Control Panel V	Rectifier V	Valves V	Electrolyzer V	
09:35	3	Test water tank Check	Preparation					
09:42	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6kg Glucose : 2.6kg Silica(TSS) :				
09:00	5	Waiting for Mixing(Test water tank)	Preparation					
10:00	6	Valve Check	Preparation					Treated & Control
09:50	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI	개/㎥ / 개/㎥		
10:08	8	Organism Injection	Preparation	ending time : 10:38				
10:10	9	TRO Analyzer Check	Preparation					
10:15	10	Valve Line up	Ballasting					Treated & Control
10:20	11	Ready for Electrolyzer	Ballasting	YES V	NO			
11:00	12	Valve Open	Ballasting					Treated & Control
11:00	13	Transfer Pump Start	Ballasting					Treated & Control
11:00	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				9.26	3.8	2450		
				9.38	3.8	2450		
				9.83	4.0	2400		
				9.54	4.0	2400		
				10.16	4.0	2400		
				9.80	4.0	2400		
				10.10	4.0	2400		
				10.24	4.0	2400		
				10.57	4.0	2400		
				10.24	4.0	2400		
				9.86	4.0	2450		
				10.25	4.0	2450		
				10:45	4.0	2450		

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : seawater-1

Test water : Sea Water(> 32PSU)　　DATE : 2017. 5. 30

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.51	4.0	2890	
				10.09	4.0	2890	
				10.11	4.0	2890	
				10.53	4.0	2860	
				10.12	4.0	2860	
				10.11	4.0	2850	
				10.36	4.0	2850	
				10.12	4.0	2850	
				10.18	4.0	2850	
				10.54	4.0	2850	
				9.12	4.0	2840	
				11.31	4.0	2840	
				10.86	4.1	2840	
				10.65	4.1	2840	
11:25	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
11:41	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:58	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
—	19	GAS Sampling of Electrolyzer	Ballasting				
—	20	GAS Sampling of Treated Tank	Ballasting				
12:00	21	Electrolysis Unit Shutdown	Ballasting				
12:00	22	Transfer Pump Stop	Ballasting				
12:00	23	Valve Close	Ballasting				Treated & Control
12:11	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : Seawater -1

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 4

Time	No.	Work	Mode	Value				Remark
11:00	1	Ready to Start	Preparation					
11:10	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
11:15	3	Treated Water Tank Check	Preparation					
—	4	GAS Sampling of Treated Tank	Preparation					
11:20	5	Treated Water Tank Sampling	Preparation					
11:30	6	Mixing of Treated Tank	Preparation					
11:40	7	Prepare of Neutralization reagent	Preparation					
12:15	8	Valve Check	Preparation					Treated & Control
12:20	9	TRO Analyzer Check	Preparation					
12:30	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				12:32		13:45		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				12:32		13:45		
12:32	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				3.12		0.04		250 ml/min
				3.54		0.03		〃
				2.69		0.04		〃
				2.90		0.08		〃
				3.81		0.05		270 ml/min
				4.08		0.06		〃
				3.82		0.05		〃
				4.19		0.06		〃
				3.84		0.05		〃
				3.88		0.05		〃
				3.88		0.06		〃
				3.84		0.04		〃
				3.84		0.05		〃
				3.89		0.04		〃

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : seawater-1

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 4

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				3.85	0.05	200 ml/min
				3.85	0.06	〃
				3.82	0.05	〃
				3.82	0.05	〃
				3.81	0.05	〃
				3.85	0.05	〃
				3.80	0.04	〃
				3.76	0.06	〃
				3.82	0.06	〃
				3.82	0.06	〃
				3.88	0.05	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 12:43	Control 14:56	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 12:59	Control 14:11	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 13:18	Control 14:24	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 13:26	Control 14:36	Treated & Control
	19	Valve Close	De-Ballasting	Treated 13:26	Control 14:36	Treated & Control
	20	Line Drain	De-Ballasting	Treated 13:29	Control 14:39	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : Seawater - 2

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 6

Time	No.	Work	Mode	Value				Remark
09:00	1	Ready to Start	Preparation					
09:05	2	System Check	Preparation	Control Panel V / Rectifier V / Valves V / Electrolyzer V				
09:05	3	Test water tank Check	Preparation					
09:08	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6 Kg Glucose : 2.6 Kg Silica(TSS) :				
09:10	5	Waiting for Mixing(Test water tank)	Preparation					
09:25	6	Valve Check	Preparation					Treated & Control
09:10	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton — KOMREI				
09:31	8	Organism Injection	Preparation					
10:05	9	TRO Analyzer Check	Preparation					
10:10	10	Valve Line up	Ballasting					Treated & Control
10:20	11	Ready for Electrolyzer	Ballasting	YES V / NO				
10:31	12	Valve Open	Ballasting					Treated & Control
10:31	13	Transfer Pump Start	Ballasting					Treated & Control
10:31	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				3.63	3.9	2870		
				10:21	3.9	2870		
				10:12	3.9	2870		
				10:13	4.0	2870		
				10:33	4.0	2870		
				10:88	4.0	2870		
				10:80	4.0	2860		
				10:46	4.1	2850		
				10:25	4.1	2850		
				10:34	4.1	2850		
				10:82	4.1	2840		
				10:65	4.1	2840		
				10:59	4.1	2840		

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : Seawater -2

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 6

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				11.08	4.1	2830	
				9.61	4.1	2810	
				10.12	4.1	2810	
				9.88	4.1	2810	
				10.20	4.1	2810	
				10.17	4.1	2810	
				10.22	4.1	2810	
				10.30	4.1	2810	
				10.12	4.1	2800	
				10.40	4.1	2800	
				10.37	4.1	2800	
				9.11	4.1	2800	
				10.58	4.1	2800	
				10.67	4.1	2800	
10:43	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
10:59	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:19	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
11:21	19	GAS Sampling of Electrolyzer	Ballasting				
11:40	20	GAS Sampling of Treated Tank	Ballasting				
11:28	21	Electrolysis Unit Shutdown	Ballasting				
11:28	22	Transfer Pump Stop	Ballasting				
11:29	23	Valve Close	Ballasting				Treated & Control
11:35	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE 김 KB호

Witnessed by : KIOST 이우진

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : Seawater →

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 11

Time	No.	Work	Mode	Value				Remark
10:00	1	Ready to Start	Preparation					
10:05	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
10:10	3	Treated Water Tank Check	Preparation					
10:12	4	GAS Sampling of Treated Tank	Preparation					
10:30	5	Treated Water Tank Sampling	Preparation					
10:34	6	Mixing of Treated Tank	Preparation					
10:40	7	Prepare of Neutralization reagent	Preparation					
10:45	8	Valve Check	Preparation					Treated & Control
10:48	9	TRO Analyzer Check	Preparation					
10:55	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				11:00		12:14		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				11:00		12:14		
11:00	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				3.41		0.04		250ml/min
				3.84		0.04		〃
				3.85		0.05		〃
				3.83		0.03		〃
				3.88		0.04		〃
				3.88		0.04		250 ml/min
				3.85		0.04		〃
				3.89		0.03		〃
				3.88		0.05		〃
				3.88		0.04		〃
				3.81		0.06		〃
				3.84		0.05		〃
				3.85		0.04		〃
				3.86		0.04		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : Secondary-2

Test water : Sea Water(> 32PSU) DATE : 2013. 6. 11

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				3.88	0.05	240 ml/min
				3.85	0.06	〃
				3.84	0.05	〃
				3.87	0.05	〃
				3.84	0.06	〃
				3.83	0.04	〃
				3.84	0.05	〃
				3.86	0.06	〃
				3.84	0.05	〃
				3.87	0.05	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 11:13	Control 12:23	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 11:30	Control 12:41	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 11:45	Control 12:55	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 11:53	Control 13:05	Treated & Control
	19	Valve Close	De-Ballasting	Treated 11:53	Control 13:05	Treated & Control
	20	Line Drain	De-Ballasting	Treated 11:54	Control 13:06	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test			Mode : Ballasting				Test No. : Seawater-3
Test water : Sea Water(> 32PSU)							DATE : 2013. 6. 13
Time	**No.**	**Work**	**Mode**	**Value**			**Remark**
08:40	1	Ready to Start	Preparation				
08:50	2	System Check	Preparation	Control Panel ✓ / Valves ✓	Rectifier ✓ / Electrolyzer ✓		
08:50	3	Test water tank Check	Preparation				
09:22	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6 Kg Glucose : 2.6 Kg Silica(TSS) : –			
09:10	5	Waiting for Mixing(Test water tank)	Preparation				
09:05	6	Valve Check	Preparation				Treated & Control
09:00	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI	[illegible] / [illegible]	
09:12	8	Organism Injection	Preparation				
09:40	9	TRO Analyzer Check	Preparation				
09:45	10	Valve Line up	Ballasting				Treated & Control
09:45	11	Ready for Electrolyzer	Ballasting	YES ✓	NO		
10:00	12	Valve Open	Ballasting				Treated & Control
10:00	13	Transfer Pump Start	Ballasting				Treated & Control
10:00	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.31	3.9	2850	
				10.48	3.9	2850	
				9.97	3.9	2850	
				10.06	4.0	2850	
				10.28	4.0	2850	
				10.26	4.0	2850	
				10.28	4.0	2850	
				10.34	4.0	2850	
				10.42	4.0	2850	
				10.23	4.0	2830	
				10.36	4.0	2830	
				10.21	4.0	2830	
				10.16	4.0	2830	

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : Seawater -3

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 13

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.23	4.0	2830	
				10.35	4.0	2830	
				10.06	4.0	2830	
				10.29	4.0	2830	
				10.35	4.0	2830	
				10.18	4.0	2830	
				10.29	4.0	2830	
				10.24	4.0	2830	
				10.39	4.0	2830	
				10.14	4.0	2810	
				10.40	4.0	2810	
				10.33	4.0	2810	
				10.28	4.0	2810	
				10.31	4.0	2810	
				10.48	4.0	2810	
10:12	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
10:28	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
10:46	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
—	19	GAS Sampling of Electrolyzer	Ballasting				
—	20	GAS Sampling of Treated Tank	Ballasting				
11:01	21	Electrolysis Unit Shutdown	Ballasting				
11:01	22	Transfer Pump Stop	Ballasting				
11:01	23	Valve Close	Ballasting				Treated & Control
11:05	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : Seawater-3

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 18

Time	No.	Work	Mode	Value				Remark
09:15	1	Ready to Start	Preparation					
09:20	2	System Check	Preparation	Control Panel	√	Neutralizer	√	
				Valves	√			
09:45	3	Treated Water Tank Check	Preparation					
—	4	GAS Sampling of Treated Tank	Preparation					
10:00	5	Treated Water Tank Sampling	Preparation					
10:02	6	Mixing of Treated Tank	Preparation					
10:10	7	Prepare of Neutralization reagent	Preparation					
10:15	8	Valve Check	Preparation					Treated & Control
10:20	9	TRO Analyzer Check	Preparation					
10:30	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				10:33		11:57		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				10:33		11:51		
10:33	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				3.24		0.05		250 ml/min
				3.13		0.05		290 ml/min
				3.83		0.04		〃
				3.85		0.04		〃
				3.86		0.06		〃
				3.96		0.09		〃
				3.96		0.08		〃
				3.93		0.08		〃
				3.91		0.06		〃
				3.85		0.09		〃
				3.91		0.06		〃
				3.92		0.09		〃
				4.00		0.06		〃
				3.91		0.09		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : Seawater -2

Test water : Sea Water(> 32PSU) DATE : 2022. 6. 18

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				2.86	0.08	200 ml/min
				2.88	0.07	〃
				2.92	0.08	〃
				2.80	0.06	〃
				2.89	0.07	〃
				2.92	0.07	〃
				2.90	0.05	〃
				2.88	0.06	〃
				2.92	0.06	〃
				2.81	0.06	〃
				2.86	0.06	〃
				2.90	0.07	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 10:41	Control: 12:02	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 11:02	Control: 12:19	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 11:19	Control: 12:33	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 11:20	Control: 12:44	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 11:20	Control: 12:44	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 11:30	Control: 12:50	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : Seawater-4

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 20

Time	No.	Work	Mode	Value			Remark
08 : 45	1	Ready to Start	Preparation				
09 : 00	2	System Check	Preparation	Control Panel √ / Rectifier √ / Valves √ / Electrolyzer √			
09 : 10	3	Test water tank Check	Preparation				
09 : 15	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6 kg Glucose : 3.6 kg Silica(TSS) : -			
09 : 05	5	Waiting for Mixing(Test water tank)	Preparation				
09 : 20	6	Valve Check	Preparation				Treated & Control
09 : 15	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton — KOMREI			
09 : 20	8	Organism Injection	Preparation				
09 : 25	9	TRO Analyzer Check	Preparation				
09 : 38	10	Valve Line up	Ballasting				Treated & Control
09 : 42	11	Ready for Electrolyzer	Ballasting	YES √	NO		
10 : 11	12	Valve Open	Ballasting				Treated & Control
10 : 11	13	Transfer Pump Start	Ballasting				Treated & Control
10 : 11	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.35	3.9	2840	
				9.28	3.9	2840	
				9.15	3.9	2840	
				10.50	3.9	2840	
				10.48	3.9	2840	
				9.85	3.9	2840	
				10.65	3.9	2840	
				10.40	3.9	2840	
				10.02	3.9	2840	
				9.95	3.9	2840	
				10.17	3.9	2840	
				10.25	4.0	2840	
				10.51	4.0	2840	

Check List for Land-Based Test Mode : Ballasting Test No. : Seawater-4

Test water : Sea Water(> 32PSU) DATE : 2013. 6. 20

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.35	4.0	2840	
				10.39	4.0	2820	
				10.51	4.0	2820	
				10.35	4.0	2820	
				10.38	4.0	2820	
				10.46	4.0	2800	
				10.35	4.0	2800	
				10.25	4.0	2800	
				10.32	4.0	2800	
				10.44	4.0	2800	
				10.54	4.0	2790	
				10.56	4.0	2790	
				10.40	4.0	2790	
				10.32	4.0	2790	
				10.46	4.0	2790	
10:28	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
10:45	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:07	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
—	19	GAS Sampling of Electrolyzer	Ballasting				
—	20	GAS Sampling of Treated Tank	Ballasting				
11:15	21	Electrolysis Unit Shutdown	Ballasting				
11:15	22	Transfer Pump Stop	Ballasting				
11:15	23	Valve Close	Ballasting				Treated & Control
11:20	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST 이억진

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : seawater -4

Test water : Sea Water(> 32PSU)　　DATE : 2013. 6. 25

Time	No.	Work	Mode	Value				Remark
09:40	1	Ready to Start	Preparation					
09:50	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
10:00	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
10:10	5	Treated Water Tank Sampling	Preparation					
10:11	6	Mixing of Treated Tank	Preparation					
10:20	7	Prepare of Neutralization reagent	Preparation					
10:23	8	Valve Check	Preparation					Treated & Control
10:28	9	TRO Analyzer Check	Preparation					
10:40	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				10:44		12:36		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				10:44		12:36		
	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				1.89		0.05		2000 ml/min
				2.33		0.04		〃
				2.37		0.02		〃
				2.48		0.01		〃
				2.49		0.03		〃
				2.49		0.02		〃
				2.54		0.00		〃
				2.57		0.01		〃
				2.53		0.01		〃
				2.53		0.00		〃
				2.48		0.01		〃
				2.53		0.03		1900 ml/min
				2.57		0.04		〃
				2.51		0.04		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : seawater-4

Test water : Sea Water(> 32PSU) DATE : 2013. 6. 25

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				2.61	0.03	190 ml/min
				2.53	0.05	〃
				2.48	0.04	〃
				2.46	0.05	〃
				2.49	0.04	200 ml/min
				2.50	0.04	〃
				2.59	0.03	〃
				2.58	0.03	〃
				2.60	0.05	〃
				2.61	0.04	〃
				2.56	0.03	〃
				2.50	0.03	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 10:55	Control 12:40	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 11:10	Control 13:01	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 11:26	Control 13:16	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 11:38	Control 13:26	Treated & Control
	19	Valve Close	De-Ballasting	Treated 11:38	Control 13:26	Treated & Control
	20	Line Drain	De-Ballasting	Treated 11:40	Control 13:30	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test | Mode : Ballasting | Test No. : Seawater-5

Test water : Sea Water(> 32PSU) | DATE : 2013. 11. 4

Time	No.	Work	Mode	Value				Remark
08:45	1	Ready to Start	Preparation					
08:50	2	System Check	Preparation	Control Panel V	Rectifier V	Valves V	Electrolyzer V	
08:50	3	Test water tank Check	Preparation					
09:00	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6 Kg Glucose : 2.6Kg Silica(TSS) : -				
09:00	5	Waiting for Mixing(Test water tank)	Preparation					
09:10	6	Valve Check	Preparation					Treated & Control
08:55	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI	3개 채취		
09:00	8	Organism Injection	Preparation					
09:48	9	TRO Analyzer Check	Preparation					
09:50	10	Valve Line up	Ballasting					Treated & Control
09:30	11	Ready for Electrolyzer	Ballasting	YES V	NO			
10:04	12	Valve Open	Ballasting					Treated & Control
10:04	13	Transfer Pump Start	Ballasting					Treated & Control
10:04	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				8.19	3.8	2840		
				9.19	4.0	2840		
				9.51	4.0	2840		
				9.86	4.0	2850		
				10.01	4.0	2850		
				9.98	4.0	2850		
				10.22	4.0	2850		
				10.15	4.0	2850		
				10.22	4.0	2850		
				10.32	4.0	2850		
				10.16	4.0	2850		
				10.45	4.0	2850		
				10.13	4.0	2830		

Check List for Land-Based Test Mode : Ballasting Test No. : Seawater-5

Test water : Sea Water(> 32PSU) DATE : 2013.11.4

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.43	4.0	2830	
				10.48	4.0	2830	
				11.12	4.0	2830	
				10.60	4.0	2800	
				10.46	4.0	2800	
				10.36	4.0	2800	
				10.57	4.0	2800	
				10.47	4.0	2790	
				10.42	4.0	2790	
				10.58	4.0	2780	
				10.61	4.0	2760	
				10.50	4.0	2760	
				10.43	4.0	2760	
				10.41	4.0	2760	
				10.61	4.0	2760	
				10.52	4.0	2760	
10:16	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
10:35	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
10:52	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
-	19	GAS Sampling of Electrolyzer	Ballasting				
-	20	GAS Sampling of Treated Tank	Ballasting				
11:03	21	Electrolysis Unit Shutdown	Ballasting				
11:03	22	Transfer Pump Stop	Ballasting				
11:03	23	Valve Close	Ballasting				Treated & Control
11:10	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : Seawater-5

Test water : Sea Water(> 32PSU)　　DATE : 2013.11.9

Time	No.	Work	Mode	Value		Remark
09:40	1	Ready to Start	Preparation			
09:50	2	System Check	Preparation	Control Panel ✓ / Valves ✓	Neutralizer ✓	
09:54	3	Treated Water Tank Check	Preparation			
-	4	GAS Sampling of Treated Tank	Preparation			
10:00	5	Treated Water Tank Sampling	Preparation			
10:00	6	Mixing of Treated Tank	Preparation			
10:15	7	Prepare of Neutralization reagent	Preparation			
10:20	8	Valve Check	Preparation			Treated & Control
10:25	9	TRO Analyzer Check	Preparation			
10:34	10	Valve Line up	De-Ballasting			Treated & Control
	11	Valve Open	De-Ballasting	Treated 10:30	Control 11:45	Treated & Control
	12	Transfer Pump Start	De-Ballasting	Treated 10:30	Control 11:45	Treated & Control
	13	Injection of Neutralization reagent	De-Ballasting			
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				1.66	0.15	190ml/min
				2.07	0.15	〃
				2.29	0.17	〃
				2.38	0.17	〃
				2.33	0.15	〃
				2.30	0.03	200ml/min
				2.42	0.04	〃
				2.39	0.03	〃
				2.35	0.02	〃
				2.54	0.04	〃
				2.40	0.03	〃
				2.45	0.05	〃
				2.40	0.03	〃
				2.47	0.04	〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : Seawater-5

Test water : Sea Water(> 32PSU) DATE : 2013. 1. 9

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				2.45	0.03	200ml/min
				2.46	0.04	〃
				2.44	0.04	〃
				2.43	0.03	〃
				2.41	0.03	〃
				2.42	0.05	〃
				2.34	0.03	〃
				2.40	0.04	〃
				2.39	0.03	〃
				2.39	0.01	〃
				2.39	0.02	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 10:39	Control 11:54	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 10:55	Control 12:10	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 11:09	Control 12:23	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 11:23	Control 12:36	Treated & Control
	19	Valve Close	De-Ballasting	Treated 11:23	Control 12:36	Treated & Control
	20	Line Drain	De-Ballasting	Treated 11:25	Control 12:40	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST 이 승 진

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : seawater-6

Test water : Sea Water(> 32PSU)　　DATE : 2013. 8. 22

Time	No.	Work	Mode	Value			Remark
09:00	1	Ready to Start	Preparation				
09:03	2	System Check	Preparation	Control Panel V / Rectifier V; Valves V / Electrolyzer V			
09:05	3	Test water tank Check	Preparation				
09:05	4	Additives Make-up in Test water tank	Preparation	Starch : 3.6 kg Glucose : 3.6 kg Silica(TSS) : -			
09:18	5	Waiting for Mixing(Test water tank)	Preparation				
09:25	6	Valve Check	Preparation				Treated & Control
09:03	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton : KOMREI			
09:17	8	Organism Injection	Preparation				
09:54	9	TRO Analyzer Check	Preparation				
09:40	10	Valve Line up	Ballasting				Treated & Control
09:50	11	Ready for Electrolyzer	Ballasting	YES V / NO			
10:10	12	Valve Open	Ballasting				Treated & Control
10:10	13	Transfer Pump Start	Ballasting				Treated & Control
10:10	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				4.98	3.8	2830	
				10.01	4.0	2830	
				10.61	4.0	2830	
				10.11	4.0	2790	
				10.15	4.0	2790	
				10.26	4.0	2790	
				10.57	4.0	2790	
				10.26	4.0	2790	
				10.59	4.0	2790	
				10.76	4.1	2790	
				10.46	4.0	2750	
				10.77	4.0	2750	
				10.71	4.0	2750	

Check List for Land-Based Test Mode : Ballasting Test No. : seawater -6

Test water : Sea Water(> 32PSU) DATE : 2013. 8. 22

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.61	4.1	>150	
				10.59	4.1	>150	
				10.62	4.0	>120	
				10.58	4.0	>120	
				10.72	4.0	>100	
				10.39	4.0	>100	
				10.48	4.0	>100	
				10.34	4.0	>65	
				10.40	4.0	>65	
				10.62	4.0	>65	
				10.47	4.0	>65	
				10.46	4.0	>65	
				11.11	4.0	>65	
				10.48	4.0	>65	
				10.44	4.0	>65	
10:22	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
10:40	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
10:58	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
—	19	GAS Sampling of Electrolyzer	Ballasting				
—	20	GAS Sampling of Treated Tank	Ballasting				
11:08	21	Electrolysis Unit Shutdown	Ballasting				
11:08	22	Transfer Pump Stop	Ballasting				
11:08	23	Valve Close	Ballasting				Treated & Control
11:15	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE 박 [illegible]

Witnessed by : KIOST 이 욱 진

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : seawater -6

Test water : Sea Water(> 32PSU)　　DATE : 2017. 8. 29

Time	No.	Work	Mode	Value				Remark
09:50	1	Ready to Start	Preparation					
10:00	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
10:15	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
10:30	5	Treated Water Tank Sampling	Preparation					
10:30	6	Mixing of Treated Tank	Preparation					
10:40	7	Prepare of Neutralization reagent	Preparation					
10:45	8	Valve Check	Preparation					Treated & Control
10:54	9	TRO Analyzer Check	Preparation					
10:55	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				11:02		12:10		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				11:02		12:10		
11:02	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				2.18		0.04		200ml/min
				2.68		0.03		〃
				2.82		0.04		200ml/min
				2.91		0.05		〃
				2.92		0.04		〃
				2.93		0.06		〃
				2.92		0.04		〃
				2.94		0.03		〃
				2.96		0.05		〃
				2.94		0.04		〃
				2.95		0.05		〃
				2.93		0.04		〃
				2.93		0.05		〃
				2.97		0.05		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : seawater-6

Test water : Sea Water(> 32PSU) DATE : 2013. 8. 27

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				2.90	0.04	2ound/min
				2.93	0.05	〃
				2.93	0.03	〃
				2.96	0.03	〃
				2.92	0.05	〃
				2.90	0.05	〃
				2.93	0.05	〃
				2.90	0.04	〃
				2.92	0.05	〃
				2.91	0.04	〃
				2.91	0.04	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 11:12	Control 12:18	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 11:28	Control 12:36	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 11:41	Control 12:50	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 11:54	Control 13:03	Treated & Control
	19	Valve Close	De-Ballasting	Treated 11:54	Control 13:03	Treated & Control
	20	Line Drain	De-Ballasting	Treated 12:00	Control 13:10	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

4.1.2 Brackish Water

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test | Mode : Ballasting | Test No. : brackish water-1

Test water : Brackish Water(< 22PSU) | DATE : 2013. 7. 11

Time	No.	Work	Mode	Value			Remark
09:00	1	Ready to Start	Preparation				
09:15	2	System Check	Preparation	Control Panel V / Rectifier V / Valves V / Electrolyzer V			
09:20	3	Test water tank Check	Preparation				
10:20	4	Additives Make-up in Test water tank	Preparation	Starch : 25Kg Glucose : 8kg Silica(TSS) : -			
10:20	5	Waiting for Mixing(Test water tank)	Preparation				
09:25	6	Valve Check	Preparation				Treated & Control
09:35	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton : KOMREI 0/ml 3783/ml			
09:50	8	Organism Injection	Preparation				
11:05	9	TRO Analyzer Check	Preparation				
11:07	10	Valve Line up	Ballasting				Treated & Control
11:05	11	Ready for Electrolyzer	Ballasting	YES V NO			
	12	Valve Open	Ballasting				Treated & Control
	13	Transfer Pump Start	Ballasting				Treated & Control
	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				11.56	4.1	3050	
				8.11	4.2	3150	
				9.52	4.2	3150	
				9.86	4.3	3150	
				10.08	4.3	3150	
				10.23	4.3	3150	
				10.20	4.3	3150	
				10.09	4.3	3150	
				10.28	4.3	3150	
				9.92	4.3	3150	
				10.00	4.3	3150	
				10.11	4.3	3150	
				10.11	4.3	3150	

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : brackishwater-1

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 1. 11

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.34	4.3	3150	
				10.02	4.3	3150	
				9.99	4.3	3150	
				9.91	4.3	3150	
				9.66	4.3	3150	
				9.61	4.3	3150	
				9.69	4.4	3150	
				9.52	4.4	3150	
				9.98	4.4	3150	
				9.99	4.4	3150	
				9.90	4.4	3150	
				9.58	4.4	3150	
				9.87	4.4	3200	
				9.81	4.4	3200	
11:22	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
11:38	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:55	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
-	19	GAS Sampling of Electrolyzer	Ballasting				
-	20	GAS Sampling of Treated Tank	Ballasting				
12:01	21	Electrolysis Unit Shutdown	Ballasting				
12:01	22	Transfer Pump Stop	Ballasting				
12:01	23	Valve Close	Ballasting				Treated & Control
12:10	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

※ 08:00 Residual chlorine check = 0.0 mg/L (three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : brackishwater -1

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 7. 16

Time	No.	Work	Mode	Value				Remark
11:10	1	Ready to Start	Preparation					
11:20	2	System Check	Preparation	Control Panel	√	Neutralizer	√	
				Valves	√			
11:25	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
11:28	5	Treated Water Tank Sampling	Preparation					
11:50	6	Mixing of Treated Tank	Preparation					
12:15	7	Prepare of Neutralization reagent	Preparation					
12:20	8	Valve Check	Preparation					Treated & Control
12:22	9	TRO Analyzer Check	Preparation					
12:28	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				12:35		13:49		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				12:35		13:49		
12:35	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				0.22		0.02		150ml/min
				0.38		0.00		〃
				0.39		0.03		100ml/min
				0.46		0.01		〃
				0.45		0.01		〃
				0.46		0.03		〃
				0.45		0.02		〃
				0.48		0.03		〃
				0.46		0.01		150ml/min
				0.46		0.01		〃
				0.46		0.04		〃
				0.46		0.00		〃
				0.47		0.02		〃
				0.46		0.02		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater-1

Test water : Brackish Water(< 22PSU) DATE : 2013. 7. 16

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.49	0.02	50ml/min
				0.53	0.01	〃
				0.47	0.03	〃
				0.45	0.03	50ml/min
				0.45	0.01	〃
				0.46	0.01	〃
				0.46	0.02	〃
				0.44	0.03	〃
				0.46	0.05	〃
				0.45	0.02	〃
				0.44	0.03	〃
				0.45	-	pump stop.
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 12:45	Control: 13:59	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 13:01	Control: 14:13	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 13:15	Control: 14:27	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 13:28	Control: 14:38	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 13:28	Control: 14:38	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 13:30	Control: 14:43	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : brackishwater-2

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 7. 18

Time	No.	Work	Mode	Value				Remark
08:59	1	Ready to Start	Preparation					
09:20	2	System Check	Preparation	Control Panel ✓	Rectifier ✓	Valves ✓	Electrolyzer ✓	
09:20	3	Test water tank Check	Preparation					
11:28	4	Additives Make-up in Test water tank	Preparation	Starch : 25kg Glucose : 8kg Silica(TSS) : –				
11:28	5	Waiting for Mixing(Test water tank)	Preparation					
09:35	6	Valve Check	Preparation					Treated & Control
09:40	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI	[illegible]		
10:00	8	Organism Injection	Preparation					
11:05	9	TRO Analyzer Check	Preparation					
11:13	10	Valve Line up	Ballasting					Treated & Control
11:27	11	Ready for Electrolyzer	Ballasting	YES	✓	NO		
12:19	12	Valve Open	Ballasting					Treated & Control
12:19	13	Transfer Pump Start	Ballasting					Treated & Control
12:19	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				6.86	4.2	3150		
				8.20	4.2	3220		
				8.24	4.3	3250		
				8.75	4.3	3300		
				7.74	4.3	3300		
				9.41	4.3	3300		
				9.66	4.4	3300		
				9.57	4.4	3300		
				9.70	4.4	3300		
				9.73	4.4	3300		
				9.34	4.4	3300		
				9.84	4.4	3300		
				9.44	4.4	3300		

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : brackishwater-2

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 9. 18

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				9.50	4.4	3300	
				9.88	4.4	3300	
				9.96	4.4	3300	
				9.91	4.4	3300	
				9.62	4.4	3300	
				9.62	4.4	3300	
				9.33	4.4	3300	
				9.34	4.4	3300	
				9.30	4.4	3300	
				9.43	4.4	3300	
				9.48	4.4	3300	
				9.23	4.4	3300	
				9.65	4.4	3300	
				9.86	4.4	3300	
12:30	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
12:47	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
13:04	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
-	19	GAS Sampling of Electrolyzer	Ballasting				
-	20	GAS Sampling of Treated Tank	Ballasting				
13:15	21	Electrolysis Unit Shutdown	Ballasting				
13:15	22	Transfer Pump Stop	Ballasting				
13:15	23	Valve Close	Ballasting				Treated & Control
13:20	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE 박 노 철

Witnessed by : KIOST 이 욱 진

※ 08:00 Residual chlorine check : 0.01 mg/L (three times)

08:50 〃 : 0.00 mg/L (three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater -2

Test water : Brackish Water(< 22PSU) DATE : 2013. 1. 23

Time	No.	Work	Mode	Value				Remark
11:50	1	Ready to Start	Preparation					
12:00	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
12:10	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
12:20	5	Treated Water Tank Sampling	Preparation					
12:21	6	Mixing of Treated Tank	Preparation					
12:25	7	Prepare of Neutralization reagent	Preparation					
12:26	8	Valve Check	Preparation					Treated & Control
12:31	9	TRO Analyzer Check	Preparation					
12:43	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				13:05		14:16		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				13:05		14:16		
13:05	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				0.32		0.04		80ml/min
				0.41		0.00		〃
				0.46		0.04		60ml/min
				0.46		0.04		〃
				0.49		0.02		50ml/min
				0.47		0.02		〃
				0.49		0.03		〃
				0.48		0.07		〃
				0.50		0.00		〃
				0.47		0.10		40ml/min
				0.48		0.09		〃
				0.46		0.09		〃
				0.48		0.03		〃
				0.49		0.03		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater -2

Test water : Brackish Water(< 22PSU) DATE : 2013. 7. 23

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.46	0.02	40ml/min
				0.48	0.05	〃
				0.48	0.04	〃
				0.49	0.04	〃
				0.49	0.00	〃
				0.48	0.02	〃
				0.47	0.06	30ml/min
				0.47	0.06	〃
				0.48	0.08	〃
				0.48	0.08	〃
				0.48	0.10	〃
				0.47	0.10	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 13:16	Control: 14:31	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 13:32	Control: 14:46	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 13:46	Control: 15:01	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 13:59	Control: 15:13	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 13:59	Control: 15:13	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 14:07	Control: 15:20	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : brackishwater-3

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 7. 25

Time	No.	Work	Mode	Value				Remark
08:20	1	Ready to Start	Preparation					
09:00	2	System Check	Preparation	Control Panel	V	Rectifier	V	
				Valves	V	Electrolyzer	V	
09:10	3	Test water tank Check	Preparation					
10:15	4	Additives Make-up in Test water tank	Preparation	Starch : 25kg Glucose : 8kg Silica(TSS) :				
10:15	5	Waiting for Mixing(Test water tank)	Preparation					
09:40	6	Valve Check	Preparation					Treated & Control
09:50	7	Check of Organism density	Preparation	Phytoplankton	KOMREI	정확히		
				Zooplankton		이상 없음		
10:03	8	Organism Injection	Preparation					
11:05	9	TRO Analyzer Check	Preparation					
11:10	10	Valve Line up	Ballasting					Treated & Control
11:13	11	Ready for Electrolyzer	Ballasting	YES	V	NO		
11:25	12	Valve Open	Ballasting					Treated & Control
11:25	13	Transfer Pump Start	Ballasting					Treated & Control
11:25	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				1.81	4.3	3250		
				9.50	4.3	3300		
				9.85	4.4	3300		
				10.10	4.4	3300		
				10.59	4.4	3300		
				10.28	4.4	3250		
				10.60	4.4	3250		
				10.63	4.4	3250		
				10.53	4.4	3200		
				10.41	4.4	3200		
				10.51	4.4	3200		
				10.51	4.4	3200		
				10.59	4.4	3200		

Check List for Land-Based Test Mode : Ballasting Test No. : brackishwater-3

Test water : Brackish Water(< 22PSU) DATE : 2013. 9. 25

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.48	4.4	3150	
				10.48	4.4	3150	
				10.04	4.4	3150	
				10.09	4.4	3150	
				10.24	4.4	3150	
				10.23	4.4	3150	
				10.28	4.4	3150	
				9.96	4.4	3150	
				10.59	4.4	3150	
				10.40	4.4	3150	
				10.35	4.4	3100	
				10.31	4.4	3100	
				10.29	4.4	3100	
				10.46	4.4	3100	
11:39	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
11:57	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
12:11	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
12:16	19	GAS Sampling of Electrolyzer	Ballasting				
12:28	20	GAS Sampling of Treated Tank	Ballasting				
12:31	21	Electrolysis Unit Shutdown	Ballasting				
12:31	22	Transfer Pump Stop	Ballasting				
12:31	23	Valve Close	Ballasting				Treated & Control
12:35	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST 이 욱 진

※ 08:14 Residual chlorine check : 0.00 mg/L (Three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : brackish water →

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 1. 30

Time	No.	Work	Mode	Value		Remark
11:05	1	Ready to Start	Preparation			
11:20	2	System Check	Preparation	Control Panel ✓ / Valves ✓	Neutralizer ✓	
11:29	3	Treated Water Tank Check	Preparation			
11:19	4	GAS Sampling of Treated Tank	Preparation			
11:32	5	Treated Water Tank Sampling	Preparation			
11:35	6	Mixing of Treated Tank	Preparation			
12:10	7	Prepare of Neutralization reagent	Preparation			
12:15	8	Valve Check	Preparation			Treated & Control
12:30	9	TRO Analyzer Check	Preparation			
12:32	10	Valve Line up	De-Ballasting			Treated & Control
	11	Valve Open	De-Ballasting	Treated 12:35	Control 13:50	Treated & Control
	12	Transfer Pump Start	De-Ballasting	Treated 12:35	Control 13:50	Treated & Control
12:35	13	Injection of Neutralization reagent	De-Ballasting			
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.29	0.06	80ml/min
				0.31	0.01	〃
				0.44	0.05	50ml/min
				0.44	0.04	〃
				0.46	0.04	〃
				0.41	0.03	〃
				0.49	0.02	〃
				0.41	0.04	〃
				0.48	0.03	〃
				0.50	0.02	〃
				0.49	0.04	30ml/min
				0.49	0.04	〃
				0.50	0.03	〃
				0.48	0.05	〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater-3

Test water : Brackish Water(< 22PSU) DATE : 2013.7.20

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.49	0.03	30ml/min
				0.47	0.04	〃
				0.50	0.01	〃
				0.49	0.02	〃
				0.46	0.03	〃
				0.48	0.04	〃
				0.46	0.04	〃
				0.49	0.04	〃
				0.47	0.04	〃
				0.48	0.06	〃
				0.48	0.04	〃
				0.48	0.03	〃
				0.52	-	pump stop
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 12:46	Control: 14:02	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 13:03	Control: 14:17	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 13:17	Control: 14:33	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 13:31	Control: 14:45	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 13:31	Control: 14:45	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 13:35	Control: 14:50	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test		Mode : Ballasting		Test No. : brackishwater-4
Test water : Brackish Water(< 22PSU)				DATE : 2013. 8. 8

Time	No.	Work	Mode	Value				Remark
08:10	1	Ready to Start	Preparation					
09:05	2	System Check	Preparation	Control Panel √	Rectifier √	Valves √	Electrolyzer √	
09:15	3	Test water tank Check	Preparation					
11:02	4	Additives Make-up in Test water tank	Preparation	Starch : 25kg	Glucose : 8kg	Silica(TSS) : -		
11:02	5	Waiting for Mixing(Test water tank)	Preparation					
10:05	6	Valve Check	Preparation					Treated & Control
10:10	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton	KOMREI	최정선	[illegible]	
10:15	8	Organism Injection	Preparation					
12:54	9	TRO Analyzer Check	Preparation					
12:58	10	Valve Line up	Ballasting					Treated & Control
13:15	11	Ready for Electrolyzer	Ballasting	YES	√	NO		
13:19	12	Valve Open	Ballasting					Treated & Control
13:19	13	Transfer Pump Start	Ballasting					Treated & Control
13:19	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				8.62	4.3	3250		
				9.92	4.3	3250		
				10.33	4.3	3250		
				9.90	4.3	3250		
				10.46	4.3	3250		
				10.77	4.3	3250		
				10.70	4.3	3200		
				10.69	4.3	3200		
				10.73	4.3	3150		
				10.89	4.3	3150		
				10.62	4.3	3100		
				10.22	4.3	3100		
				10.44	4.3	3100		

Check List for Land-Based Test Mode : Ballasting Test No. : brackishwater -4

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 8

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.64	4.3	3100	
				10.68	4.3	3100	
				10.41	4.3	3100	
				10.22	4.3	3100	
				10.15	4.3	3100	
				10.36	4.3	3100	
				10.37	4.3	3100	
				10.31	4.3	3100	
				10.38	4.3	3100	
				10.49	4.3	3100	
				10.35	4.3	3100	
				10.41	4.3	3100	
				10.44	4.3	3100	
13:20	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
13:49	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
14:02	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
-	19	GAS Sampling of Electrolyzer	Ballasting				
-	20	GAS Sampling of Treated Tank	Ballasting				
14:15	21	Electrolysis Unit Shutdown	Ballasting				
14:15	22	Transfer Pump Stop	Ballasting				
14:15	23	Valve Close	Ballasting				Treated & Control
14:20	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

※ 08:10 Residual Chlorine check : 0.00mg/L (three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : brackishwater -4

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 8. 13

Time	No.	Work	Mode	Value				Remark
12:50	1	Ready to Start	Preparation					
12:55	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
13:00	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
13:23	5	Treated Water Tank Sampling	Preparation					
13:23	6	Mixing of Treated Tank	Preparation					
13:25	7	Prepare of Neutralization reagent	Preparation					
13:36	8	Valve Check	Preparation					Treated & Control
13:55	9	TRO Analyzer Check	Preparation					
13:57	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				14:00		15:10		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				14:00		15:10		
	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				0.19		0.05		20ml/min
				0.20		0.04		〃
				0.24		0.04		〃
				0.23		0.04		〃
				0.22		0.05		〃
				0.24		0.05		〃
				0.24		0.01		〃
				0.25		0.02		〃
				0.26		0.02		〃
				0.25		0.04		〃
				0.20		0.03		〃
				0.22		0.03		〃
				0.23		0.02		〃
				0.25		0.05		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater-4

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 13

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.23	0.04	30ml/min
				0.23	0.04	〃
				0.24	0.04	〃
				0.22	0.06	〃
				0.23	0.03	〃
				0.22	0.01	〃
				0.24	0.06	〃
				0.22	0.02	〃
				0.25	0.03	〃
				0.22	0.02	〃
				0.22	0.03	〃
				0.21	-	pump stop
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 14:09	Control: 15:24	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 14:26	Control: 15:41	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 14:41	Control: 15:56	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 14:54	Control: 16:07	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 14:54	Control: 16:07	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 15:00	Control: 16:10	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : brackishwater-5

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 8. 15

Time	No.	Work	Mode	Value			Remark
08:10	1	Ready to Start	Preparation				
09:15	2	System Check	Preparation	Control Panel V / Rectifier V; Valves V / Electrolyzer V			
09:25	3	Test water tank Check	Preparation				
09:55	4	Additives Make-up in Test water tank	Preparation	Starch : 25kg Glucose : 8kg Silica(TSS) :			
09:55	5	Waiting for Mixing(Test water tank)	Preparation				
09:40	6	Valve Check	Preparation				Treated & Control
09:45	7	Check of Organism density	Preparation	Phytoplankton / Zooplankton : KOMREI			
10:02	8	Organism Injection	Preparation				
10:30	9	TRO Analyzer Check	Preparation				
10:35	10	Valve Line up	Ballasting				Treated & Control
10:35	11	Ready for Electrolyzer	Ballasting	YES V / NO			
10:40	12	Valve Open	Ballasting				Treated & Control
10:40	13	Transfer Pump Start	Ballasting				Treated & Control
10:40	14	Electrolysis Unit Start	Ballasting				
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				6.79	4.3	3250	
				8.06	4.5	3250	
				8.85	4.5	3300	
				9.43	4.5	3300	
				10.22	4.6	3300	
				10.31	4.6	3300	
				10.62	4.6	3300	
				10.69	4.5	3300	
				10.25	4.5	3300	
				10.55	4.5	3300	
				10.53	4.5	3300	
				10.33	4.5	3150	
				10.40	4.5	3150	

Check List for Land-Based Test			Mode : Ballasting	Test No. : brackishwater -5			
Test water : Brackish Water(< 22PSU)				DATE : 2013. 8. 15			
Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.36	4.5	3150	
				10.57	4.5	3150	
				10.65	4.5	3150	
				10.42	4.5	3150	
				10.48	4.5	3150	
				10.17	4.5	3150	
				9.81	4.5	3150	
				10.03	4.5	3150	
				9.86	4.5	3150	
				9.87	4.6	3150	
				10.24	4.6	3150	
				10.11	4.6	3150	
				10.11	4.6	3150	
				10.24	4.6	3150	
				10.48	4.6	3150	
10:52	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
11:10	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:25	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
–	19	GAS Sampling of Electrolyzer	Ballasting				
–	20	GAS Sampling of Treated Tank	Ballasting				
11:38	21	Electrolysis Unit Shutdown	Ballasting				
11:38	22	Transfer Pump Stop	Ballasting				
11:38	23	Valve Close	Ballasting				Treated & Control
11:45	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE	강 나 호 (signature)
Witnessed by : KIOST	최 조 정 (signature)

※ 07:57 Residual chlorine check = 0.00 mg/L (Three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : brackishwater -5

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 8. 20

Time	No.	Work	Mode	Value		Remark
10:10	1	Ready to Start	Preparation			
10:15	2	System Check	Preparation	Control Panel V / Neutralizer V Valves V		
10:30	3	Treated Water Tank Check	Preparation			
—	4	GAS Sampling of Treated Tank	Preparation			
10:40	5	Treated Water Tank Sampling	Preparation			
10:40	6	Mixing of Treated Tank	Preparation			
10:50	7	Prepare of Neutralization reagent	Preparation			
10:55	8	Valve Check	Preparation			Treated & Control
11:00	9	TRO Analyzer Check	Preparation			
11:05	10	Valve Line up	De-Ballasting			Treated & Control
	11	Valve Open	De-Ballasting	Treated: 11:16	Control: 12:16	Treated & Control
	12	Transfer Pump Start	De-Ballasting	Treated: 11:16	Control: 12:16	Treated & Control
11:16	13	Injection of Neutralization reagent	De-Ballasting			
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.18	0.15	30ml/min
				0.17	0.17	〃
				0.17	0.03	50ml/min
				0.18	0.02	〃
				0.16	0.04	〃
				0.17	0.03	30ml/min
				0.17	0.04	〃
				0.18	0.05	30ml/min
				0.18	0.04	〃
				0.16	0.05	〃
				0.17	0.04	〃
				0.16	0.05	〃
				0.14	0.03	〃
				0.17	0.06	〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater -5

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 20

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.16	0.05	20ml/min
				0.18	0.06	〃
				0.18	0.04	〃
				0.17	0.04	〃
				0.16	0.04	〃
				0.15	0.05	〃
				0.15	0.04	〃
				0.17	0.04	〃
				0.15	0.03	〃
				0.16	0.05	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated 11:22	Control 12:28	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated 11:38	Control 12:43	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated 11:53	Control 12:58	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated 12:06	Control 13:09	Treated & Control
	19	Valve Close	De-Ballasting	Treated 12:06	Control 13:09	Treated & Control
	20	Line Drain	De-Ballasting	Treated 12:10	Control 13:15	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test Mode : Ballasting Test No. : brackishwater-6

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 28

Time	No.	Work	Mode	Value				Remark
09:00	1	Ready to Start	Preparation					
09:15	2	System Check	Preparation	Control Panel	V	Rectifier	V	
				Valves	V	Electrolyzer	V	
09:30	3	Test water tank Check	Preparation					
12:00	4	Additives Make-up in Test water tank	Preparation	Starch : 25 kg Glucose : 8 kg Silica(TSS) : -				
12:00	5	Waiting for Mixing(Test water tank)	Preparation					
12:15	6	Valve Check	Preparation					Treated & Control
10:00	7	Check of Organism density	Preparation	Phytoplankton	KOMREI	[illegible]		
				Zooplankton		[illegible]		
10:15	8	Organism Injection	Preparation					
12:42	9	TRO Analyzer Check	Preparation					
12:40	10	Valve Line up	Ballasting					Treated & Control
12:43	11	Ready for Electrolyzer	Ballasting	YES	V	NO		
12:50	12	Valve Open	Ballasting					Treated & Control
12:50	13	Transfer Pump Start	Ballasting					Treated & Control
12:50	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				10.69	4.4	3280		
				9.39	4.3	3250		
				10.22	4.4	3250		
				10.72	4.4	3250		
				10.77	4.3	3150		
				10.31	4.4	3150		
				10.48	4.4	3100		
				10.12	4.4	3100		
				10.17	4.4	3100		
				10.13	4.4	3100		
				10.74	4.4	3100		
				10.00	4.4	3100		
				9.90	4.4	3100		

Check List for Land-Based Test Mode : Ballasting Test No. : brackishwater-6

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 29

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.62	4.4	3100	
				10.26	4.4	3100	
				10.11	4.4	3100	
				9.94	4.4	3100	
				10.08	4.4	3100	
				9.90	4.4	3100	
				9.96	4.5	3150	
				10.19	4.5	3150	
				10.21	4.5	3150	
				10.21	4.5	3150	
				10.48	4.5	3150	
				10.33	4.5	3150	
				10.28	4.5	3150	
				10.40	4.5	3150	
				10.68	4.5	3150	
13:02	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
13:20	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
13:39	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
-	19	GAS Sampling of Electrolyzer	Ballasting				
-	20	GAS Sampling of Treated Tank	Ballasting				
13:41	21	Electrolysis Unit Shutdown	Ballasting				
13:47	22	Transfer Pump Stop	Ballasting				
13:47	23	Valve Close	Ballasting				Treated & Control
13:55	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

※ 09:20 Residual chlorine check : 0.00mg/L (Three times)

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : brackishwater-6

Test water : Brackish Water(< 22PSU)　　DATE : 2013. 8. 3

Time	No.	Work	Mode	Value				Remark
12:00	1	Ready to Start	Preparation					
12:20	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
12:35	3	Treated Water Tank Check	Preparation					
-	4	GAS Sampling of Treated Tank	Preparation					
12:50	5	Treated Water Tank Sampling	Preparation					
12:50	6	Mixing of Treated Tank	Preparation					
12:55	7	Prepare of Neutralization reagent	Preparation					
13:00	8	Valve Check	Preparation					Treated & Control
13:15	9	TRO Analyzer Check	Preparation					
13:10	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				13:23		14:34		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				13:23		14:34		
	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				0.34		0.00		10ml/min
				0.35		0.01		50 ml/min
				0.34		0.00		〃
				0.39		0.00		〃
				0.38		0.00		30ml/min
				0.36		0.09		〃
				0.40		0.01		〃
				0.39		0.01		〃
				0.43		0.00		〃
				0.41		0.01		〃
				0.40		0.06		〃
				0.40		0.01		〃
				0.41		0.03		〃
				0.36		0.03		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : brackishwater-6

Test water : Brackish Water(< 22PSU) DATE : 2013. 8. 3

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.31	0.08	30 ml/min
				0.38	0.08	〃
				0.31	0.01	〃
				0.40	0.00	〃
				0.39	0.03	〃
				0.38	0.02	〃
				0.39	0.08	〃
				0.31	0.18	〃
				0.31	0.02	〃
				0.38	0.01	〃
				0.39	0.01	〃
				0.35	0.01	〃
				0.42	-	pump stop
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 13:29	Control: 14:38	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 13:49	Control: 14:58	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 14:02	Control: 15:12	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 14:18	Control: 15:28	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 14:18	Control: 15:28	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 14:25	Control: 15:30	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST 이 욱 진

4.1.3 Low Salinity Water

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test Mode : Ballasting Test No. : low salinity

Test water : Low Salinity Water DATE : 2012. 9. 12

Time	No.	Work	Mode	Value				Remark
09:45	1	Ready to Start	Preparation					
10:00	2	System Check	Preparation	Control Panel	V	Rectifier	V	
				Valves	V	Electrolyzer	V	
10:10	3	Test water tank Check	Preparation					
10:30	4	Additives Make-up in Test water tank	Preparation	Starch : 25 Kg Glucose : 8 kg Silica(TSS) :				
10:30	5	Waiting for Mixing(Test water tank)	Preparation					
10:00	6	Valve Check	Preparation					Treated & Control
09:55	7	Check of Organism density	Preparation	Phytoplankton	KOMREI	이상		
				Zooplankton		적합		
10:15	8	Organism Injection	Preparation					
11:06	9	TRO Analyzer Check	Preparation					
11:08	10	Valve Line up	Ballasting					Treated & Control
11:00	11	Ready for Electrolyzer	Ballasting	YES	V	NO		
11:12	12	Valve Open	Ballasting					Treated & Control
11:12	13	Transfer Pump Start	Ballasting					Treated & Control
11:12	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				8.23	5.1	3700		
				9.09	5.2	3700		
				10.11	5.2	3700		
				9.49	5.2	3700		
				10.13	5.2	3700		
				9.84	5.2	3700		
				10.11	5.2	3700		
				9.92	5.2	3700		
				10.05	5.2	3700		
				10.04	5.2	3700		
				9.30	5.2	3700		
				9.96	5.2	3700		
				9.94	5.2	3700		

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : low salinity

Test water : Low Salinity Water　　DATE : 2013. 9. 12

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.15	5.2	3600	
				10.01	5.2	3600	
				9.89	5.2	3600	
				9.95	5.2	3600	
				9.60	5.2	3600	
				9.86	5.2	3600	
				10.04	5.2	3660	
				9.84	5.2	3660	
				10.13	5.2	3660	
				10.04	5.3	3660	
				10.18	5.3	3660	
				10.15	5.3	3660	
				10.15	5.3	3660	
				10.31	5.3	3660	
				10.22	5.3	3660	
11:21	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
11:39	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
11:56	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
12:00	19	GAS Sampling of Electrolyzer	Ballasting				
12:16	20	GAS Sampling of Treated Tank	Ballasting				
12:11	21	Electrolysis Unit Shutdown	Ballasting				
12:11	22	Transfer Pump Stop	Ballasting				
12:11	23	Valve Close	Ballasting				Treated & Control
12:15	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : low salinity

Test water : Low Salinity Water　　DATE : 2013. 5. 19

Time	No.	Work	Mode	Value				Remark
10:40	1	Ready to Start	Preparation					
10:42	2	System Check	Preparation	Control Panel	V	Neutralizer	V	
				Valves	V			
10:50	3	Treated Water Tank Check	Preparation					
11:00	4	GAS Sampling of Treated Tank	Preparation					
11:13	5	Treated Water Tank Sampling	Preparation					
11:17	6	Mixing of Treated Tank	Preparation					
11:20	7	Prepare of Neutralization reagent	Preparation					
11:25	8	Valve Check	Preparation					Treated & Control
11:30	9	TRO Analyzer Check	Preparation					
11:33	10	Valve Line up	De-Ballasting					Treated & Control
/	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				11:46		12:55		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				11:46		12:55		
11:46	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				0.39		0.00		5mL/min
				0.49		0.02		3mL/min
				0.52		0.06		〃
				0.55		0.04		〃
				0.56		0.08		〃
				0.58		0.05		〃
				0.57		0.02		〃
				0.58		0.03		〃
				0.59		0.02		〃
				0.54		0.01		〃
				0.61		0.04		〃
				0.58		0.02		〃
				0.59		0.03		〃
				0.58		0.00		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : low salinity

Test water : Low Salinity Water DATE : 2013. 8. 11

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				0.55	0.01	20ml/min
				0.54	0.00	〃
				0.56	0.01	〃
				0.59	0.00	〃
				0.53	0.01	〃
				0.56	0.00	〃
				0.54	0.00	〃
				0.59	0.00	〃
				0.54	0.01	〃
				0.56	0.01	〃
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated	Control	Treated & Control
				11:55	12:05	
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated	Control	Treated & Control
				12:09	13:22	
	17	Monitoring of Sampling(end)	De-Ballasting	Treated	Control	Treated & Control
				12:24	13:30	
	18	Transfer Pump Stop	De-Ballasting	Treated	Control	Treated & Control
				12:31	13:40	
	19	Valve Close	De-Ballasting	Treated	Control	Treated & Control
				12:37	13:41	
	20	Line Drain	De-Ballasting	Treated	Control	Treated & Control
				12:40	13:50	

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : Ballasting　　Test No. : low salinity - 2

Test water : Low Salinity Water　　DATE : 2013. 10. 10

Time	No.	Work	Mode	Value				Remark
09 : 50	1	Ready to Start	Preparation					
10 : 10	2	System Check	Preparation	Control Panel	V	Rectifier	V	
				Valves	V	Electrolyzer	V	
10 : 15	3	Test water tank Check	Preparation					
11 : 40	4	Additives Make-up in Test water tank	Preparation	Starch : 1kg Glucose : 8kg Silica(TSS) :				
11 : 40	5	Waiting for Mixing(Test water tank)	Preparation					
10 : 40	6	Valve Check	Preparation					Treated & Control
10 : 05	7	Check of Organism density	Preparation	Phytoplankton	KOMREI	부족		
				Zooplankton		부족		
11 : 25	8	Organism Injection	Preparation					
12 : 10	9	TRO Analyzer Check	Preparation					
12 : 15	10	Valve Line up	Ballasting					Treated & Control
12 : 15	11	Ready for Electrolyzer	Ballasting	YES	V	NO		
12 : 55	12	Valve Open	Ballasting					Treated & Control
12 : 55	13	Transfer Pump Start	Ballasting					Treated & Control
12 : 55	14	Electrolysis Unit Start	Ballasting					
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current		
				9.16	5.3	3600		
				9.18	5.3	3600		
				9.08	5.4	3600		
				9.38	5.4	3700		
				9.31	5.5	3700		
				9.03	5.5	3700		
				9.32	5.5	3700		
				9.37	5.5	3600		
				9.80	5.5	3600		
				9.64	5.5	3600		
				10.25	5.5	3600		
				9.81	5.5	3600		
				10.02	5.45	3600		

Check List for Land-Based Test Mode : Ballasting Test No. : low salinity-2

Test water : Low Salinity Water DATE : 2013. 10. 10

Time	No.	Work	Mode	Value			Remark
	15	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.42	5.5	3600	
				9.81	5.5	3600	
				9.38	5.5	3600	
				9.66	5.5	3600	
				9.05	5.5	3600	
				9.39	5.5	3600	
				9.43	5.5	3600	
				8.45	5.6	3600	
				9.75	5.6	3600	
				8.68	5.6	3600	
				9.03	5.6	3600	
				9.02	5.6	3600	
				8.84	5.6	3600	
				8.48	5.6	3600	
13:09	16	Monitoring of Sampling(beginning)	Ballasting				Treated & Control
13:25	17	Monitoring of Sampling(middle)	Ballasting				Treated & Control
13:39	18	Monitoring of Sampling(end)	Ballasting				Treated & Control
—	19	GAS Sampling of Electrolyzer	Ballasting				
—	20	GAS Sampling of Treated Tank	Ballasting				
13:54	21	Electrolysis Unit Shutdown	Ballasting				
13:54	22	Transfer Pump Stop	Ballasting				
13:54	23	Valve Close	Ballasting				Treated & Control
14:00	24	Line Drain	Ballasting				Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

De-Ballasting Operation Log Sheet

Check List for Land-Based Test　　Mode : De-Ballasting　　Test No. : low salinity - 2

Test water : Low Salinity Water　　DATE : 2013. 10. 15

Time	No.	Work	Mode	Value				Remark
12:20	1	Ready to Start	Preparation					
12:35	2	System Check	Preparation	Control Panel	√	Neutralizer	√	
				Valves	√			
12:45	3	Treated Water Tank Check	Preparation					
—	4	GAS Sampling of Treated Tank	Preparation					
12:55	5	Treated Water Tank Sampling	Preparation					
13:55	6	Mixing of Treated Tank	Preparation					
13:00	7	Prepare of Neutralization reagent	Preparation					
13:15	8	Valve Check	Preparation					Treated & Control
13:22	9	TRO Analyzer Check	Preparation					
13:34	10	Valve Line up	De-Ballasting					Treated & Control
	11	Valve Open	De-Ballasting	Treated		Control		Treated & Control
				13:36		14:48		
	12	Transfer Pump Start	De-Ballasting	Treated		Control		Treated & Control
				13:36		14:48		
13:36	13	Injection of Neutralization reagent	De-Ballasting					
	14	TRO Check(each 2 minute)	De-Ballasting	Before		After		
				1.18		0.05		50ml/min
				1.29		0.09		〃
				1.42		0.04		〃
				1.43		0.04		〃
				1.44		0.03		〃
				1.44		0.03		〃
				1.42		0.04		〃
				1.41		0.04		〃
				1.46		0.07		〃
				1.45		0.05		〃
				1.54		0.02		〃
				1.46		0.03		〃
				1.43		0.09		〃
				1.49		0.02		〃

Check List for Land-Based Test Mode : De-Ballasting Test No. : low salinity - 2

Test water : Low Salinity Water DATE : 2013. 10. 15

Time	No.	Work	Mode	Value		Remark
	14	TRO Check(each 2 minute)	De-Ballasting	Before	After	
				1.43	0.03	ppb/min
				1.48	0.03	〃
				1.45	0.03	〃
				1.41	0.05	〃
				1.43	0.04	〃
				1.45	0.03	〃
				1.48	0.04	〃
				1.41	0.03	〃
				1.52	0.00	〃
				1.41	0.02	〃
				1.40	0.02	〃
				1.42	0.04	
	15	Monitoring of Sampling(beginning)	De-Ballasting	Treated: 13:45	Control: 14:59	Treated & Control
	16	Monitoring of Sampling(middle)	De-Ballasting	Treated: 14:02	Control: 15:15	Treated & Control
	17	Monitoring of Sampling(end)	De-Ballasting	Treated: 14:16	Control: 15:32	Treated & Control
	18	Transfer Pump Stop	De-Ballasting	Treated: 14:29	Control: 15:40	Treated & Control
	19	Valve Close	De-Ballasting	Treated: 14:29	Control: 15:40	Treated & Control
	20	Line Drain	De-Ballasting	Treated: 14:35	Control: 15:50	Treated & Control

Reported By : KT MARINE

Witnessed by : KIOST

4.1.4 Low Temperature Water

KT MARINE BWMS Check List for Land-Based Test(Final Approval)

Ballasting Operation Log Sheet

Check List for Land-Based Test Mode : Ballasting Test No. : Low Temperature-

Test water : Sea Water(> 32PSU) DATE : 2012. 12. 29

Time	No.	Work	Mode	Value						Remark
22:20	1	Ready to Start	Preparation							
22:25	2	System Check	Preparation	Control Panel	√	Rectifier	√			
				Valves	√	Electrolyzer	√			
22:40	3	Test water tank Check	Preparation							
22:50	4	Temperature check of Test water tank	Preparation							Basis : 250㎥
22:20	5	Waiting for Mixing(Test water tank)	Preparation							
22:55	6	Valve Check	Preparation							Treated
23:00	7	TRO Analyzer Check	Preparation							
23:05	8	Valve Line up	Ballasting							Treated
23:10	9	Ready for Electrolyzer	Ballasting	YES	√	NO				
23:11	10	Valve Open	Ballasting							Treated
23:11	11	Transfer Pump Start	Ballasting							Treated
23:11	12	Electrolyzer Unit Start	Ballasting							
	13	TRO Check(each 2 minute)	Ballasting	TRO value		Voltage		Current		
				10.01		4.3		2500		
				10.11		4.3		2500		
				10.22		4.3		2500		
				10.10		4.3		2450		
				10.11		4.3		2450		
				10.24		4.3		2450		
				10.24		4.3		2450		
				10.44		4.3		2450		
				10.01		4.3		2400		
				10.15		4.3		2400		
				10.18		4.3		2400		
				10.10		4.3		2400		
				10.01		4.3		2400		
				10.01		4.3		2400		
				10.16		4.3		2400		

Check List for Land-Based Test Mode : Ballasting Test No. : Low temperature

Test water : Sea Water(> 32PSU) DATE : 2013. 12. 27

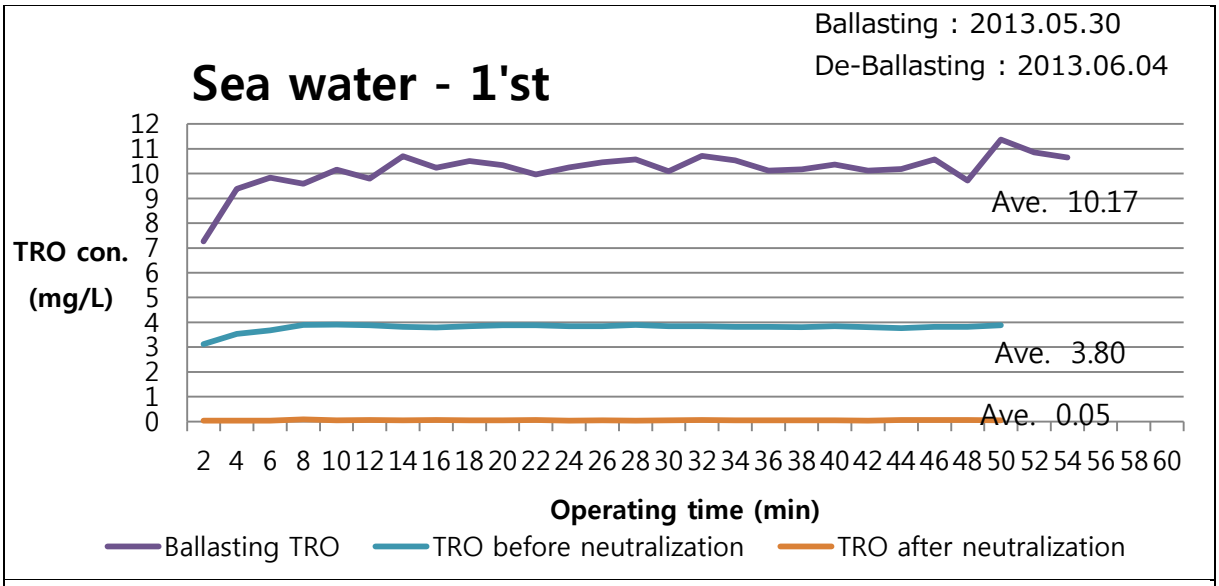
Time	No.	Work	Mode	Value			Remark
	13	TRO Check(each 2 minute)	Ballasting	TRO value	Voltage	Current	
				10.13	4.3	240V	
				10.17	4.3	240V	
				9.66	4.3	240V	
				10.32	4.3	240V	
				10.24	4.3	240V	
				10.31	4.3	240V	
				10.22	4.3	240V	
				10.23	4.3	240V	
				10.29	4.3	240V	
				10.19	4.3	240V	
				10.16	4.3	240V	
				10.45	4.3	240V	
24:05	14	Electrolyzer Unit Shutdown	Ballasting				
24:07	15	Transfer Pump Stop	Ballasting				
24:09	16	Valve Close	Ballasting				Treated
24:15	17	Line Drain	Ballasting				Treated

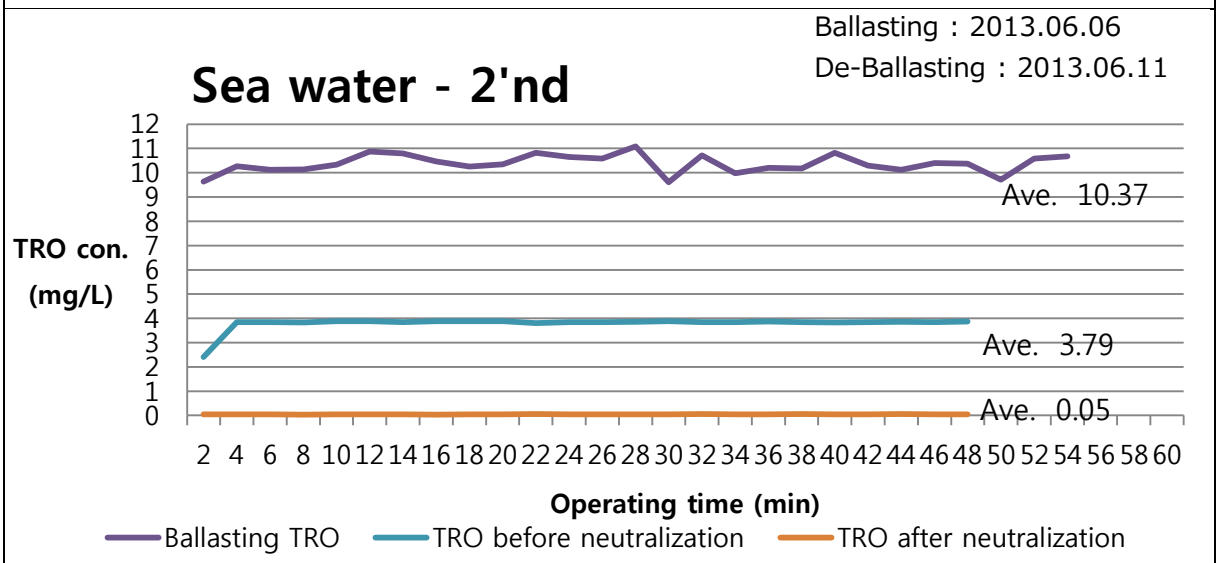
Reported By : KT MARINE

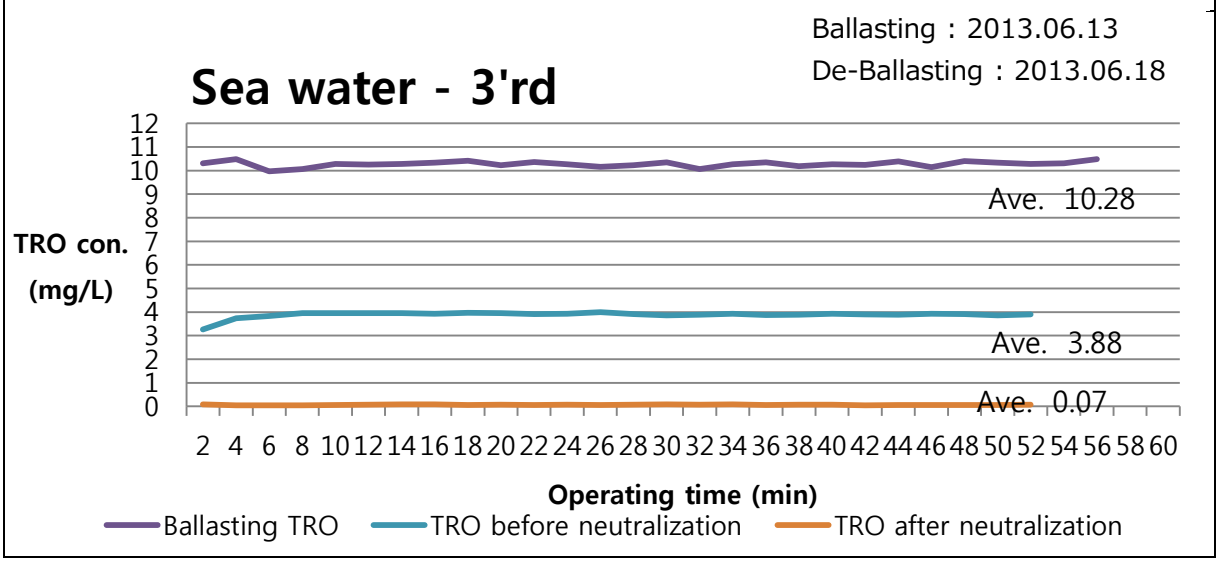
Witnessed by : KIOST 이 석 진

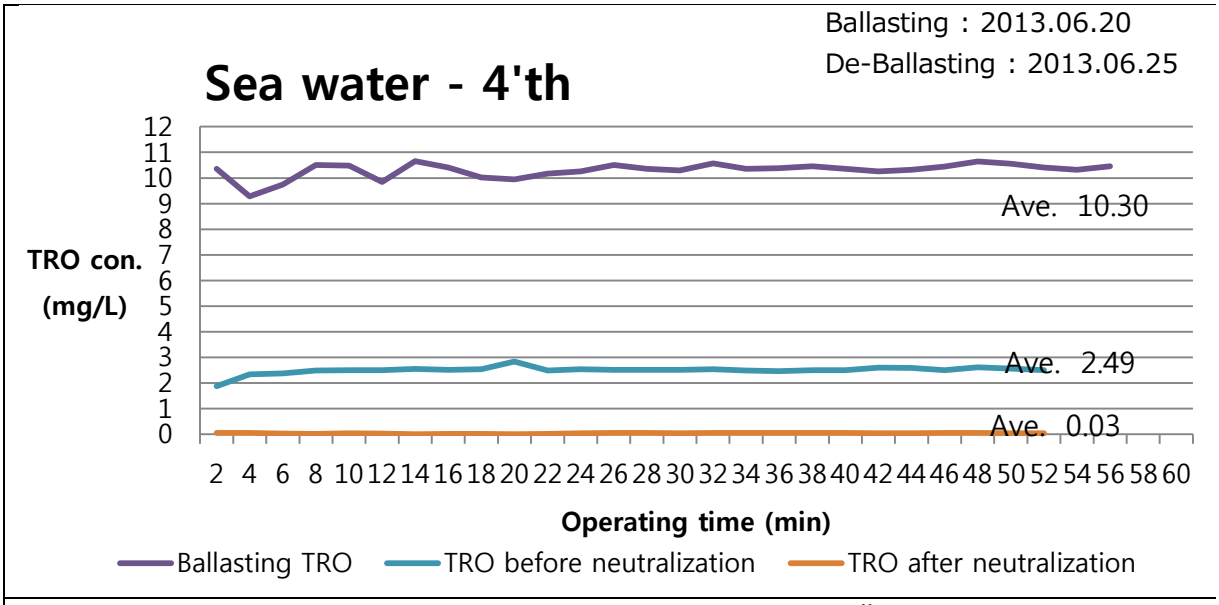
4.2 TRO Concentration Monitoring Graph

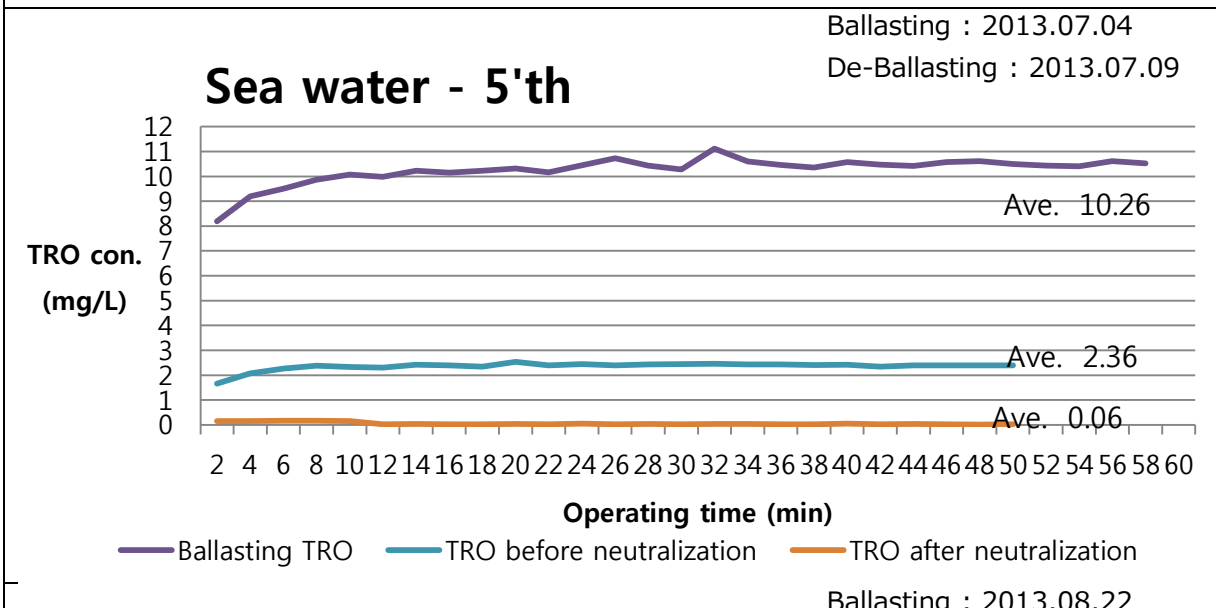
4.2.1 Sea Water

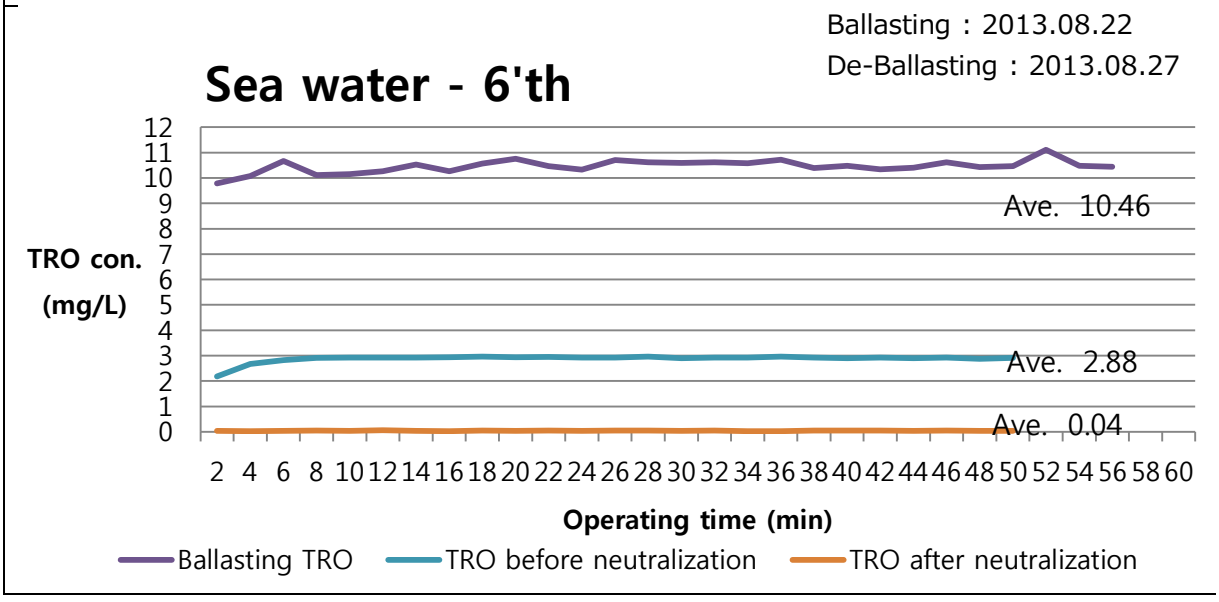




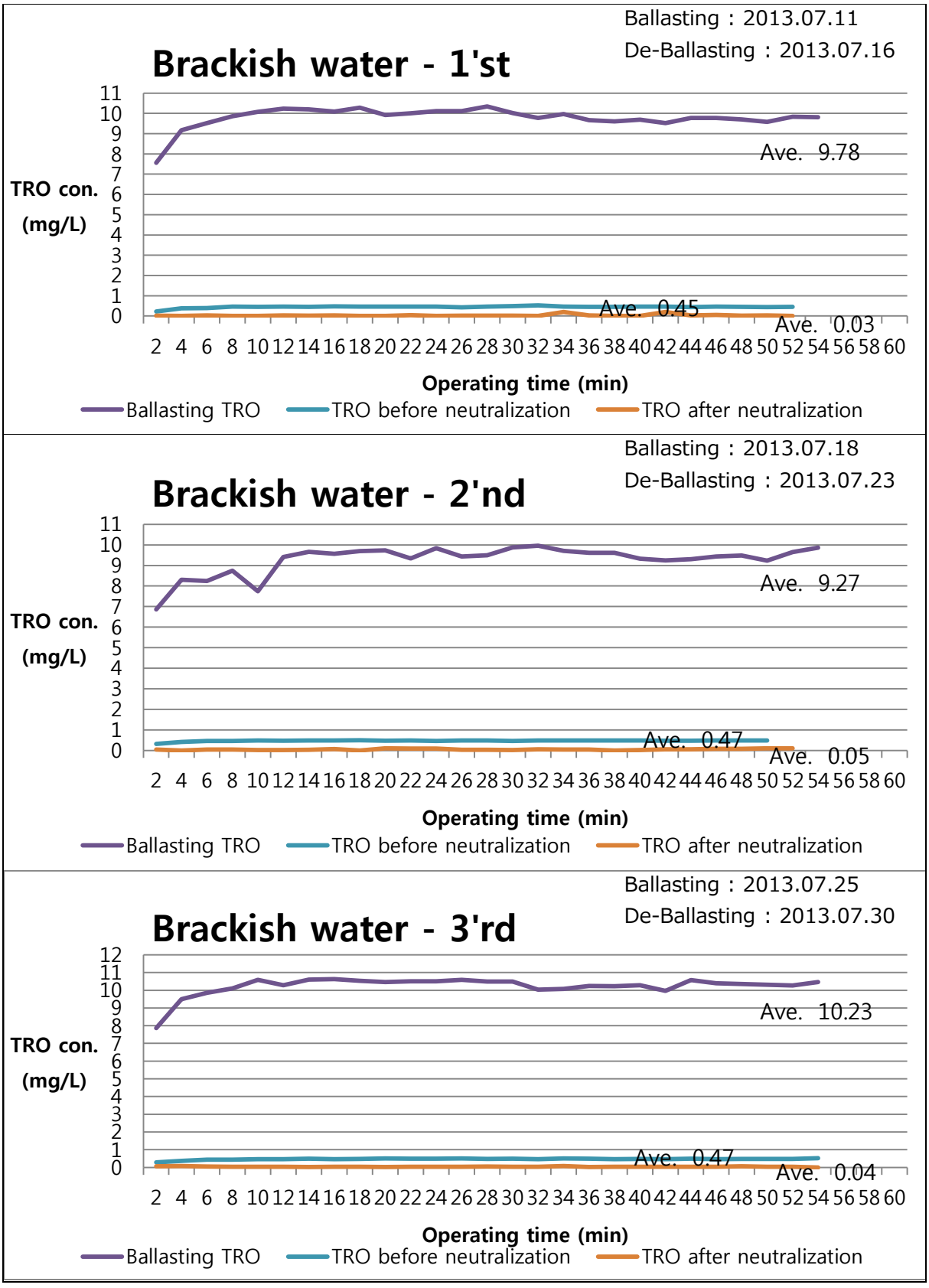


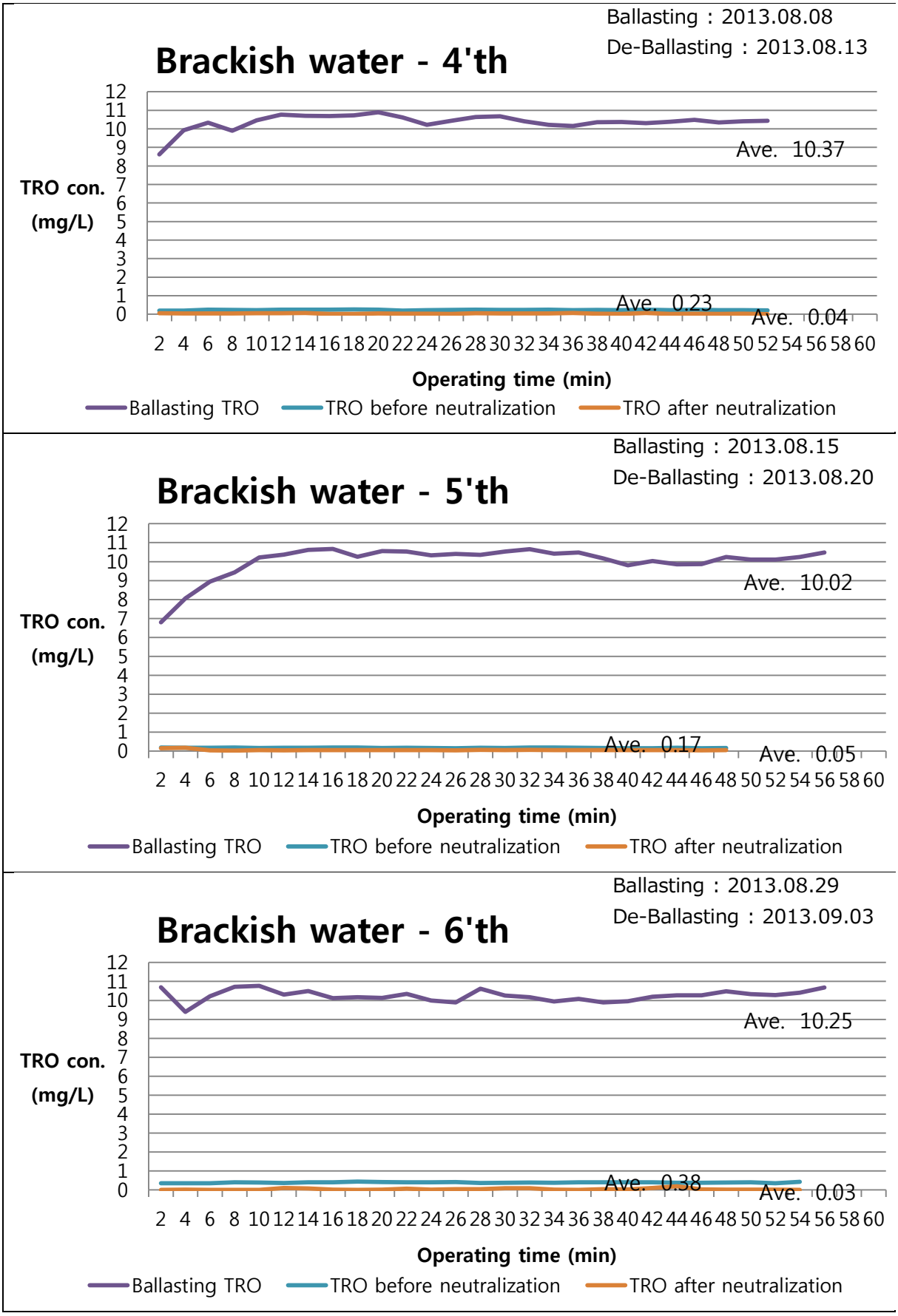

Ballasting : 2013.06.20
De-Ballasting : 2013.06.25
Sea water - 4'th
TRO con. (mg/L)
Ave. 10.30
Ave. 2.49
Ave. 0.03
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization


Ballasting : 2013.07.04
De-Ballasting : 2013.07.09
Sea water - 5'th
TRO con. (mg/L)
Ave. 10.26
Ave. 2.36
Ave. 0.06
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization

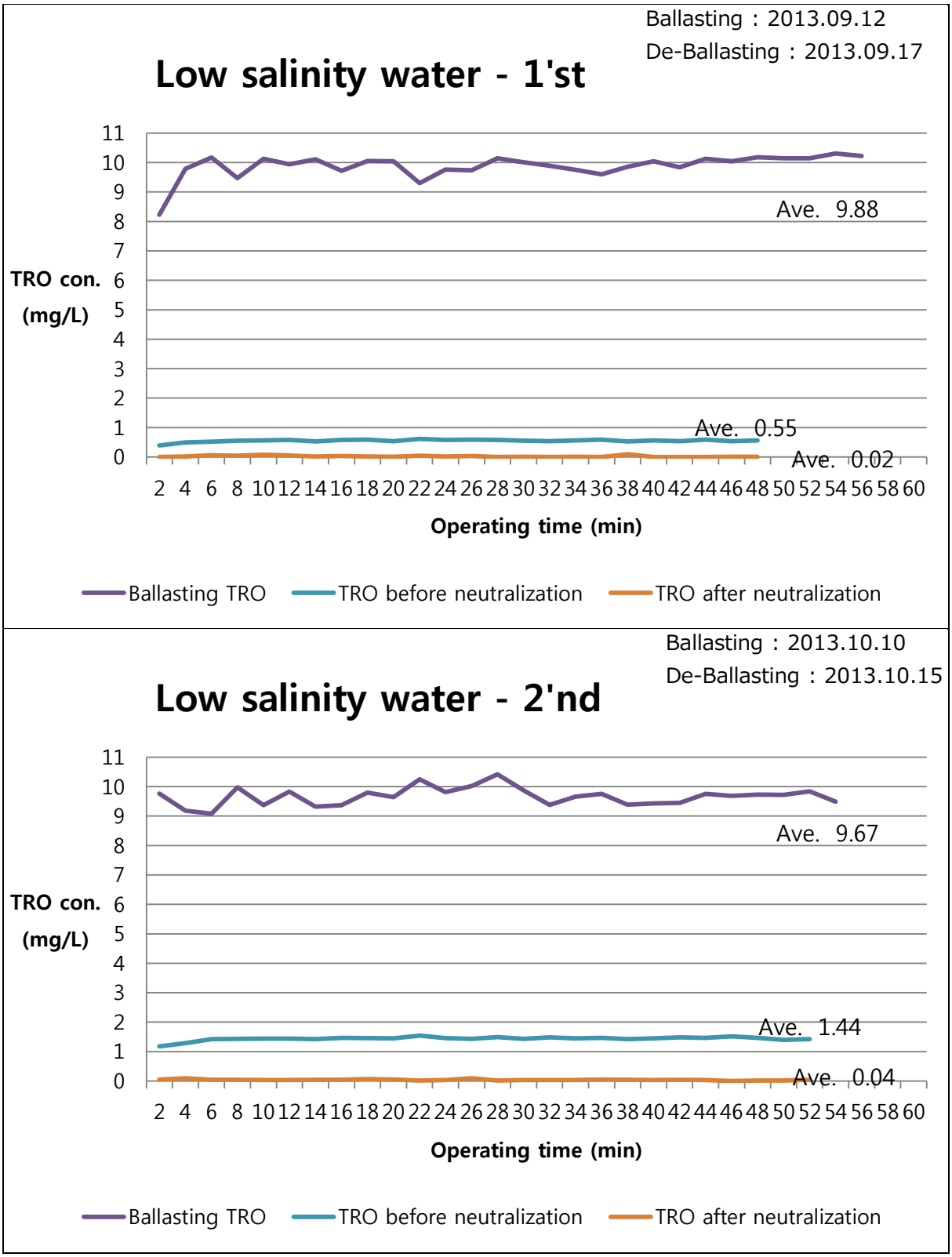

Ballasting : 2013.08.22
De-Ballasting : 2013.08.27
Sea water - 6'th
TRO con. (mg/L)
Ave. 10.46
Ave. 2.88
Ave. 0.04
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization

4.2.2 Brackish Water




Ballasting : 2013.08.08
De-Ballasting : 2013.08.13
Brackish water - 4'th
TRO con. (mg/L)
Ave. 10.37
Ave. 0.23
Ave. 0.04
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization
Ballasting : 2013.08.15
De-Ballasting : 2013.08.20
Brackish water - 5'th
TRO con. (mg/L)
Ave. 10.02
Ave. 0.17
Ave. 0.05
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization
Ballasting : 2013.08.29
De-Ballasting : 2013.09.03
Brackish water - 6'th
TRO con. (mg/L)
Ave. 10.25
Ave. 0.38
Ave. 0.03
Operating time (min)
Ballasting TRO
TRO before neutralization
TRO after neutralization

4.2.3 Low Salinity Water



4.2.4 Low Temperature Water